SHAFT SINKING UNDER DIFFICULTIES AT DORCHESTER BAY TUNNEL, BOSTON, MASS.*

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The body of this paper will be devoted to a detail of actual experience in shaft building under difficult circumstances; but that the existing local conditions may be better understood we will commence by a short general sketch of the work with which these shafts are immediately connected.

The system of improved sewerage, now being carried out by the city of Bostom, is too extensive and complex in its ramifications to be treated of in this paper. We will, therefore, begin at the pumping station on Old Harbor Point, the terminus of the low-grade intercepting sewers.

The sewage, in passing from the pumping station to the point of final delivery on Moon Island, must cross under Dorchester Bay, a navigable arm of Boston harbor, about two miles wide from shore to shore; and to this end an inverted syphon or submarine tunnel becomes necessary.

After an examination into the geological formation of this region, it was determined to locate the horizontal portion of the syphon at a sufficient depth below the surface of the water to be entirely contained *within* the rock which was found to underlie the bay. This determination fixed the average invert grade of the finished tunnel about 142 ft. below mean low tide, or Boston City datum. The ship channel is only 18 ft. deep at low water, but the material overlying the rock was mud, clay, sand and gravel, so irregular in its deposit, and so unreliable in its general character, that tunneling through it was an impossibility with the Atlantic ocean practically overhead.

The rock to be passed through belongs to the clay-slates, with, so far, infrequent strata of very hard conglomerates. But at some remote period this ancient sea floor, in taking its present trough-like shape, has been subjected to enormous pressures, much disturbing the original stratification, breaking the beds in many places and leaving them tilted at high angles to the horizon. The numerous faults consequent on this action, have generally well filled again by injective material, but crevices, fortunately slight in extent, are frequent, which communicate more or less directly with a water-bearing stratum of sand, gravel and boulders, which seems to be continuous over the surface of the rock. Wherever cut by the tunnel section, these seams allow a greater or less percolation of sea water into the workings below, amounting at his date (July, 1881), to 1½ millions of gallons daily, which can, of course, only be removed by constant pumping; the length of the tunnel now excavated being 4,600 ft.

The lower plate is a general profile of the tunnel, and shows the rock dipping rapidly from east to west. To meet this rock at as high an elevation as possible, the western, or inlet shaft, was pushed out about 1,400 ft. from the Boston shore of the bay, and connection made between it and the pumping station, by a high-grade tank sewer, founded upon an embankment, and protected by rip-rap and a sea-wall. Four pumps, of a capacity of 25,000,000 gallons each, daily, will raise the sewage a height of about 43 ft., and deliver it into this tank-sewer, the invert grade of which is 15.5 ft. above city datum. This tank is double, each section being 8 ft. wide by 16 ft. high, and the interior is provided with a series of dams, which will intercept any heavy material that may pass through the screens provided at the entrance to the pump well. Either compartment of the tank can be shut off by gates, and cleaned, and by means of stop planks the velocity head can be greatly increased and the tank sewer used to flush out the tunnel, sea-water being pumped into the tank for this purpose.

At the inlet shaft, the bottom of which is 142 ft. below datum, the tunnel commences, and runs in a south-eastwardly direction for a distance of 6,090 ft., to the center of the east shaft, the bottom of which is 144 ft. below datum; at this latter point the tunnel grade commences to rise at the rate of 1 ft. vertical in 6 ft. horizontal, and continues at this grade for a further horizontal distance of 903 ft., until the tunnel pierces the surface of the ground on Squantum Head, which forms the eastern side of Dorchester Bay.

At the eastern terminus of the tunnel, the invert grade is 14.4 ft. above datum, and from this point the sewer is continued in an open cut across Squantum Head, and then on an embankment over the shoal water lying between the Head and Moon Island, to the collecting basin on the island, from which basin the sewage is emptied into the bay at each ebb tide by an appropriate system of gates and outfall chambers. The point of discharge is four and one-half miles in a direct line from the State House in Boston.

DIMENSIONS OF TUNNEL AND SHAFTS.—The tunnel and the shafts are circular in section, with a finished inside diameter of 7 ft. 6 in. The tunnel and shaft excavation, as at first taken out, is as near as may be 9 ft. 6 in. in diameter, provision being thus made for a final lining of brick work throughout, 12 in. thick, for the purpose of reducing friction. This brick work is intended to be water tight, and at the inlet shaft gates and an outfall sewer will be built, leading from the tank sewer, so that the sewage can be discharged directly into the bay at this point and the tunnel pumped out, examined and cleansed, when such a proceeding may be deemed necessary. To intercept any solid matter that may pass into the tunnel, a sump 6 ft. deep is provided at the bottom of the east shaft, and consequently at the foot of the incline, from which sump the material may be removed by dredging through the shaft. The middle shaft, shown on the profile, is simply for working purposes, and may be finally filled up.

BULKHEADS ABOUT SHAFTS—As all the shafts are located in water, from 3 ft. to 15 ft. in depth, depending upon the state of the tide, bulkheads were necessary, from which to commence operations, and to protect the mouth of the shaft from damage by storm, ice, passing vessels, etc. As shown at Figs. 1 and 2, Plate I., these bulkheads consisted substantially of a box 20 ft. square inside, formed of oak piles driven 2½ ft. apart from centers, and capped by 12-in. × 12-in. hard-pine sticks, framed at the corners, and drift-bolted to the head of each pile. These caps were further secured at the corners by 12-in. × 12-in. angle-braces, dovetailed into them. The box was lined inside by 4-in. tongued and grooved sheet-piling, driven to hard bottom, and well spiked to four lines of 4 in. × 10-in. inside wale pieces. Outside of the piles were two sets of 12-in. × 12-in. hard-pine timbers, spaced 4 ft. apart vertically, and bolted to the piles by 1¼-in. bolts, and tied at the corners of each set by 2-in. diagonal rods. The top of this bulkhead was 18 ft. above mean low tide, the average rise and fall of tide being 10 ft. After the iron cylinder had been started within this box, the space surrounding the cylinder was compactly filled with puddle clay.

THE IRON CYLINDERS.—To quote from the specifications, "iron cylinders were to be sunk to a depth sufficient to give them a firm bearing, to insure the exclusion of tide-water, and to pass through ground otherwise difficult to excavate." These cylinders are 9 ft. 6 in. inside diameter, 1¾ in. thick, and cast in solid sections 5 ft. long. The flanges are 5¾ in. wide over all, 2 in. thick, and faced true for a width of 4⅜ in. in from the exterior edge. A groove ⅛ in. wide, and 1⅜ in. deep, was left between any two abutting cylinders, on the inside, to be caulked with lead if found necessary. The sections were connected by thirty turned bolts, 1⅛ in. diameter, in each joint, and the bottom section in each shaft was provided with a cutting edge, 12 in. deep. The weight of each section was 5 tons, or 1 ton to the lineal foot of iron cylinder. The joints were made water-tight, by first painting them with thick red lead, and then passing four turns of cotton wicking, dipped in the paint, around the outside line of the bolt holes; grummets of the same wicking, dipped in paint, were put under the heads and nuts of all the connecting bolts. These joints proved perfectly water-tight.

SINKING THE CYLINDERS.—After the bulkheads were completed, pile wharves had to be built adjoining them, upon which to place the hoisting engines, boilers, coal bins, fresh-water tanks, etc. To handle the five-ton cylinder sections, four stout shear-poles were erected, resting on the corners of the bulkhead and meeting at the top, over the center of the proposed shaft, where the ends were secured by rope-lashing (Fig. 1, Plate I). A hoisting tackle of two triple-sheaved "masting-blocks," and 4-in. manilla rope was suspended from the apex of these shears. Owing to delay in obtaining the proper kind of clay filling, and to avoid the increased friction as well, the first five cylinder sections in each shaft were put in place by means of friction clamps, as shown at Fig. 2, Plate I. These clamps were made of two compound beams of hard-pine timber, thrown across the bulkhead, one each side of the cylinder. Each beam was composed of three 12-in. × 20-in. sticks, the inner one of each beam being carefully fitted to the outside of the cylinder; to increase the friction, four vertical timbers, 12-in. × 12-in. and 4 ft. long, were bolted to the inside of the beams, as shown on the plan. The clamps were drawn together and made to hold any object between them, by tightening up the nuts on two 2½-in. iron rods that passed through the beams, one each side of the cylinder section. We should here remark that, owing to its resinous nature, hard pine is not well adapted for use in that part of the beam touching the cylinder; white pine is much better, but in our case could not be obtained in time of the required dimensions. The method of operating these friction clamps was as follows: No. 1 section was first lowered down between the beams, and clamped fast. No. 2 section was next lowered down upon No. 1, the joint made, and the connecting bolts put in and screwed up; with the hoisting tackle still attached to the last section as a "preventer," the two sections were allowed to slip down between the clamp beams in a series of short jumps, by carefully slackening and then tightening the nuts on the clamp-rods with a long wrench. A little practice enabled the workmen to keep the mass under perfect control. When No. 2 section occupied the place in the clamps previously held by No. 1, the nuts were screwed up tight, the tackle cast off, and the third section bolted on, and lowered in like manner. This process was repeated until the cutting edge on the first section had reached hard bottom, when the clamps were loosened, and thereafter utilized as guides.

HANDLING THE MATERIAL EXCAVATED.—Before the permanent hoisting cages were put in place, the material excavated in sinking the shafts, and in driving a considerable portion of the tunnel as well, was handled by an arrangement shown at Fig. 1, Plate I. This was simply an out-haul, working through a single block lashed to the head of a mast planted in the bulkhead; this mast leaned outward at the top—over the side of the bulkhead. In using this arrangement, the bucket is hoisted a distance above the shaft, fixed by experiment—the out-haul being hooked on to the bucket just as it reaches the mouth of the shaft—and the slack hauled in as the bucket ascends; when the bucket stops, the end of the out-hall is made fast to a cleat on the mast, and the bucket in descending will pass through a curve regulated by the length of the out-hall, until it hangs vertically from the top of the mast, and over the sides of the bulkhead, where it can be dumped. A reversal of this process will bring the bucket again to the top of the shaft, where the out-haul is unhooked, and the bucket lowered to the bottom for refilling.

SINKING WEST OR INLET SHAFT.—All of the foregoing description applies to the three shafts, generally. We will now confine our remarks to the west shaft, where the depth of the material overlying the rock was greatest, and the difficulty of sinking in like degree increased.

Previous to the letting of the contract, test borings had been made over the line of the tunnel by the city of Boston, and the results exhibited.

Owing to the great expense of so doing, these borings in no place penetrated the rock proper, and, therefore, they failed to give any certain indication of the presence, at each shaft at least, of a stratum of boulders, sand and gravel, lying immediately on the rock, and containing a large body of water. At this west shaft, especially, the worst feature shown by the borings was a sandy clay. The tunnel grade had to be finally lowered 8½ ft. below contract grade to meet this changed condition of affairs.

The material was actually deposited at the west shaft, in about the following sequence: Commencing at the top, mud 3 ft., pure sand 5 ft., and then strata of varying thicknesses of pure, tough clay—clay with thin seams of fine sand, and clay intimately mixed with sand. Above the surface of the solid rock, and meeting the clay and sand deposits, was a stratum 14 ft. thick, of large boulders, gravel and very sharp sand, and in this lowermost stratum water to the amount of about 17,000 gallons per hour was found. This water was salt and seemingly in direct communication with the bay above.

In the sand seams struck before the boulder stratum was tapped, brackish water, in maximum quantity not exceeding 200 gallons per hour, was found, but these seams generally drained out and gave little or no trouble. The surface of the solid rock was finally located at the west shaft 123 ft. below city datum.

Seven cylinder sections, making 35 lineal feet of iron shafting, were sunk without much trouble, but at this point the frictional resistance of the clay was sufficient to prevent any further sinking of the iron lining by its own weight merely, although the material was excavated below the cutting edge. At this time the surface water was entirely excluded, and the shaft was dry. A dead weight of at first 50 tons was now applied as follows: On top of the flanges forming the second cylinder joint, or 10 ft. from the bottom of the shaft, a platform was built, made of 4 12-in. × 12-in. hard pine sticks, laid in pairs, parallel to each other, leaving a 6-in. space between the two sticks in each pair, and a space of 4 ft. between the pairs. These four sticks were accurately fitted to the inside of the cylinder with as great a bearing surface on the flanges as was possible, holes being made in them for the heads of the cylinder bolts. Two struts 12 in. × 12 in. and 4 ft. long, were let in between the pairs, and at right angles to them, so as to leave a central opening 4 ft. square, opposite the ends of these struts and between the sticks forming the pairs, four wedges were now driven and the whole structure thus secured in the cylinder. A shaft 4 ft. square inside, made of 4-in. plank, on end, and internally braced, was next erected on this platform, and the space outside this box shaft well packed with iron refuse from a puddling furnace. As the cylinder descended and the friction became greater, this dead weight was

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increased to a little over 100 tons by putting in a second platform and box higher up in the shaft. Eight heavy screw-jacks were also applied, in addition to this weight, on the top flange of the cylinder, reacting against trussed beams, secured by chains to the bulkhead piles.

When the cutting edge of the shaft-lining had reached a point 57 feet below city datum, the area of surface then exposed to possible friction being over 1,800 sq. ft., all our combined appliances failed to push it any further, and the use of the specified solid iron cylinders had to be discontinued.

CONTINUATION OF THE SHAFT TO ROCK.—No plan whatever of continuing the shaft after the cylinders were pushed as far as was possible being specified, the contractor was at liberty to adopt any method that might seem to him most fitting. From the data before him timber was deemed sufficient, and a timber lining was adopted: the shaft was dry, all water from above excluded, and nothing but clay indicated below him until the rock was reached. Of the wisdom of this decision we will here say nothing, considering that all the known data was derived from deep borings —which more often lead to trouble than exhibit the actual condition of affairs.

The timber shaft was 10 ft. square inside, and built of 12 in.×12 in. spruce timber, laid skin to skin. As shown at Fig. 4, Plate II., the sticks were cut and laid in alternate lengths of 10 ft. and 12 ft., locking over each other at the corners, and to prevent the shorter timbers from being forced inward they abutted against cleats 4 in × 10 in.×16 in., well spiked to the long sticks. They were further held in place by the bracing described further on.

The first timber course laid was only 8 ft. 10 in. square inside, each succeeding course stepping back 2 in., until the full dimension of 10 ft. square was reached. This was done to give the cutting edge of the iron cylinders a bearing on top of the timber work, at least in the center of the four sides. Between the top course of the timber-work and the iron, a space 4 in. wide was left, in which 4-in. sheet piling was driven out horizontally into the clay and the corners outside the circle thus closed.

The greatest difficulty to be dealt with from the start, and the chief objection against such a compound shaft of iron and wood, was that of properly connecting the two. The corners of a square wooden shaft are the points best adapted for the location of any suspending members, but in our case these corners were outside the cylinder, and, consequently, not available. At first four of the cylinder bolts were removed from the bottom joint in the cylinder and replaced by four 1¼-in. rods, with nuts at the top and lipped plates, catching under the bottom of the second timber course, and secured by 1-in. rag bolts to this course; below this the hanging was continued by vertical plank spiked to the timbers.

As the shaft increased in length, these 1¼-in. rods were supplemented by four rods 2 in. in diameter, suspended opposite the center of each side of the shaft, from heavy iron castings, bolted on top of the second cylinder joint. An iron plate 6 in.×¾in. and 8 ft. long, was bolted by eight 1-in. bolts, to the middle of each side, and at the top of this plate was an L-shaped head 8 in. 1×½ in., through which the 2-in. rod passed, and was there secured by a nut.

This timber shaft was sunk with very little trouble to a point 95 ft. below datum, with a maximum quantity of water from the thin sand seams not exceeding 200 gallons per hour. But at the point first mentioned, water suddenly burst in from below at the rate of about 10,000 gallons per hour, driving out the workmen and rapidly filling the shaft, to low-tide mark. A steam pump was at once put in place and the shaft again emptied. An examination showed that, while the source was at some point below the bottom of the shaft, the water had in places forced its way up behind the timbering and was entering the shaft in jets through every possible crevice. And, what was worse, the main stream was undermining the sides at the bottom, and the jets above were washing the fine sand inside, leaving voids outside the shaft-lining. The sides were at once calked, and the water driven to the bottom, and the 8 in. × 8 in. bracing, only partly in place, was completed to within 4 ft. of the bottom. The iron cylinder soon commenced to sink very slowly, showing that the ground surrounding the shaft was in motion clear to the surface. The bulkhead and the adjoining portion of the machinery wharf sank with the cylinder.

The bottom was now a sandy clay, the water passing to the southwest corner of the shaft as soon as we commenced resinking. The material to the east and north side seemed to drain out and remain quite firm, while on the other sides it soon became very soft, in places semi-fluid. This action increased the strain on the soft sides and tended to throw the timber courses out of the horizontal, the west side sinking more rapidly than the east. As long as the bottom remained firm, this inequality of settlement was arrested by "rakers" and "props." All timbering on the soft sides could only be put in place by first carefully poling those sides, but surplus material would escape inside, and increase the pressures. All went well enough under the circumstances until we reached grade 104, when we suddenly struck a stratum of soft, almost dough-like clay, which we afterwards found was the direct covering of the water-bearing stratum of boulders, etc. Into this soft material our rakers, props, etc., easily sank and became useless as supports, and thereby the strain upon the rods and hanging members on the soft sides was enormously increased, and the west and south 2-in. rods both broke, just above the lower nuts; the immediate cause being the slight bending of the L-shaped heads of the straps, thus acting as levers on the nuts and ends of the rods. Some of the plank lacing also commenced to give way, and, being behind the corner bracing, could not be repaired.

Two steam pumps, a No. 8 Blake, and a No. 10 Knowles, were at this time located in the timber portion of the shaft, supported upon platforms, the discharge and steam pipes were clamped to both the iron cylinder and to the sides of the wooden shaft. As soon as the 2-in. rods broke, severing the connection on those sides between the iron and the wood, the lower portion began to settle more rapidly than the cylinder. The effect of this was to break the bottom elbow on the discharge column of our large pump, flooding the lower portion of the shaft to the height of the suction on our reserve pump, the No. 8, at a very critical period. This damage was repaired as soon as possible, and a re-occurrence of the accident prevented by slinging both of our pumps by wire rope to the iron cylinder, and wedging up between pump and platform as the wooden shaft settled.

On sounding through the soft stratum hard bottom was found about 7 ft. below the then bottom of the shaft, and, as this was very near the point which the boring indicated as rock, we continued sinking. After some tedious and dangerous work, and much trouble and delay from our pumps, which, as is usually the case, were always breaking down just when most needed, we reached the hard bottom only to find it was not ledge rock, but the top of a boulder stratum, of then unknown depth, and the source from whence came all our water, now much increased in quantity. The sand in this deposit was unusually sharp, and would scour through a brass pump lining ¼ in. thick in less than three days, causing further and dangerous delays.

We attempted to sound the boulder stratum by driving iron bars, but failed to get any satisfactory results until we started an artesian boring in a 5-in. pipe, and finally drilled some 8 ft. into the rock, establishing its actual depth and character.

At this time the bottom portion of our timber shaft was in very bad shape, many timbers broken, the hanging appliances a failure, and the courses very much out of the horizontal. To continue sinking under these conditions was to invite certain disaster. On the other hand, if we stopped sinking, the only alternative to building a new shaft in another location was the somewhat desperate one of attempting to retimber the lower 36 ft. of the shaft in the face of the moving ground and the consequent pressures. We determined to retimber without waiting for the ground to settle.

The upper 23 ft. of the timber work was still in good condition, the courses almost level, and the lacing intact. This portion we concluded to leave in, but it had, first of all, to be securely connected with the iron cylinders, and upon the integrity of this connection all success depended. Iron rods were abandoned in our plans for several reasons, among these the difficulty of attachment, and the fact that in one place certain obstructions in the shaft prevented a fair lead. Iron-wire cables were substituted for rods. Four cables, made by Roebling Bros., were at first used, each cable 6¾ in. in circumference and 22½ ft. long from bearing to bearing of the eyes, and thimbles spliced into each end. The upper eye was made heart-shaped, so that the lashing to be used would not ride and cut under the strain to be put upon it, the lower eye was made to take a 2-in. iron pin, and the splices on each cable were further secured by broad iron clamps bolted over them. On top of the first or lowermost cylinder joint, two hard pine timbers, 12-in. × 20-in., were placed, after having first been accurately fitted to the inside of the cylinder; holes were bored vertically through these sticks, just clearing the cylinder flanges, and passing through these holes, secured above by nuts and 12-in. cast-iron washers, were four eye-bolts made of 2½-in round iron; two struts were driven between the 12-in. × 20-in timbers, to prevent motion.

The lower connection for the cables was more troublesome. At the point selected, two hard-pine beams, 12-in. × 20-in. and 12 ft. long, were inserted in the shaft horizontally, the ends extending out under the sides. These two beams ran in the same direction as the shorter beams in the cylinder, and were vertically under them. Around each of the 12-ft. beams, and directly under the eye-bolts, were four iron stirrups, each 6 in. by 1 in., with two eyes in each stirrup just over the center of the beam.

Between these eyes the lower end of the cable was inserted and secured by a 2-in. iron pin. The upper eye of each cable was now lashed to its proper eye-bolt by steel wire rope set taut by a purchase connected with the hoisting engine.

The connection being now completed between the iron cylinder and the 26 ft. of wood work to be left in place, the workmen commended replacing the old cripled timbers, below the hanging beams, with new and level courses; in other words, rebuilding the lower portion of the shaft. As shown on Fig. 1, plate II., a system of timber hanging was first attempted with 4-in. plank, which plank acted at the same time as struts for the corner braces. This system was soon abandoned. It was all right theoretically, and had it been as easy of application in the shaft as on paper, would no doubt have answered admirably, but in practice it was found impossible, under the circumstances, to keep the inside faces of the timbers sufficiently true to plank against in the manner intended. The same principle was, however, retained by using iron straps 3 in. × ⅜ in., and 4 ft. long, spiked with 10-in. wrought-iron spikes to the timber. These straps were applied in the corners behind the braces, in such manner that each new stick was suspended by two of these straps as soon as it was in place—4 ft of the bottom of the shaft was necessarily left unbraced for convenience in working.

A second set of hanging timbers was put in 20 ft. below the first, and entirely independent of that set (Fig. 1, Plate II.). In this set each hanging beam was made up of two 12 by 12 in. timbers, placed one on top of the other; the upper one was 12 ft. long and passed through the sides of the shaft, the lower one was 10 ft. long, and acted as a strut as well. Two 2-in. iron rods, about 10 ft. long, each provided with an eye for a 2-in. pin above and a nut below, secured the lower end of each secondary cable to the beams. These rods, in pairs, carried the compound beams between them, the lower ends of each pair of rods passing through a stirrup plate 8 by 1½ in. under the bottom stick, and there secured by nuts. These cables were galvanized iron wire 4½ in. in circumference. They were lashed at the upper end to four 2-in. eye-bolts, which passed through castings bolted on to the second cylinder joint.

This re-timbering was slow and dangerous work, and the greatest care possible in poling could not prevent the escape of some of the outside material into the shaft. The voids thus created, though comparatively slight, kept the ground in constant motion, the settlement being apparent clear to the surface. The first wire cables soon became as taut as harp strings. At first the greatest weight was thrown on the western pair of cables, leaving the east cables comparatively slack; the strain on the cables was equalized by setting up rakers, extending from the heavy west side to the east end of the main hanging-beams. The total settlement of the iron cylinder after the timbering was commenced was just 5 ft.

The timber shaft was in the above manner successfully carried down to the solid rock, the shaft continued 20 ft. into the rock and the tunnel commenced. About five months after the completion of the timber-work the brick lining was commenced. To conform to required lines it was necessary to cut entirely through some of the shaft timbers, and at the center we found the clay outside generally drained, and in good condition. In the time specified above, the brick-work was completed with but little trouble from any motion in the adjoining ground; caution, however, was required, and the work was slowly and carefully done.

PUMPING OUT SHAFTS.—The west and the east shafts were at different times filled with water; the first was lost by a failure of our boilers, the other by suddenly uncovering an unusually large seam in the rock, through which more water entered the tunnel than could be handled with safety by the two pumps then in place—one of the pumps broke down under the hard work, and the tunnel and shaft filled up. All of our shafts were too small in diameter, when their depth and the quantity of water to be raised through them is considered. This want of shaft room made our method of regaining them somewhat peculiar, and we will relate our experience.

When the eastern shaft was flooded the amount of water to be pumped against was 18,000 gallons per hour, constantly flowing into the tunnel. To handle this quantity of water with safety, under the working conditions, would require a pump of the capacity of a No. 11 Knowles, which measures 9 ft. over all, and would require an additional 2½ ft. of room at the water end to allow packing, etc. It can be readily seen that such a pump could not be located horizontally within the iron cylinders, which, as before mentioned, were only 9 ft. 6 in. in diameter, a space further reduced by the flanges to 8 ft. 10 in.

To overcome this difficulty we had a special pump built by the Knowles Company, of the bucket and plunger type, double-acting and working vertically. This pump had a 14-in. steam cylinder, 12-in. plunger, 17-in. bucket and 24-in. stroke; its capacity was 11¾ gallons per stroke. (The steam cylinder proved too small for the work to be done; it should have been 16 in.) The pump was 12 ft. long over all, and 3 ft. in diameter at the widest part, and with 20 ft. of thin wrought-iron suction pipe 10 in. in diameter attached, weighed 7,000 lbs. The steam pipe was 2-in., the exhaust 3-in., and the discharge column was 6-in. galvanized-iron spiral pipe in 16-ft. lengths, connected by flanges and 6 ⅝-in. bolts.

On account of its shape this pump was used without platforms built in the shaft. Two heavy beams were thrown across the top of the shaft cylinders, and from these the pump was suspended by a purchase made up of two large triple-sheaved masting blocks, and six parts of 4-in. Manilla rope, connection with the pump being made by a strong eye-bolt screwed into the head of the steam cylinder, and by chain slings passing down to the water barrel of the pump. The running end of this purchase passed from the lower block up to a large single block lashed to the top of the four-legged shears, shown at Fig. 1, Plate I., and from there down to the wharf, and through a snatch-block to the drum of the hoisting engine. The 6-in. discharge column, and the 2-in. steam pipe were clamped to separate steel wire ropes, that were secured to the pump below, and thence passed over sheaves lashed to the shears near the top, but as far apart as possible; from these sheaves each rope went through a snatch-block on the wharf, and then to large cleats, all so arranged that each rope could be paid out steadily, and independently, as the pump was lowered. The exhaust steam passed into the water. To keep the pump from moving laterally when it was at work, oak slides, with clamping screws, were attached to the pump, so that they could be pushed out against the sides of the shaft and then clamped. The spreading of the blocks to which the discharge and steam pipes were suspended was to overcome the twisting tendency in the falls.

The method of operating this pump was as follows: When the water in the shaft had been pumped down as low as possible, the steam was shut off at the boiler, the top elbow and a 10-ft. length of horizontal pipe was taken off from the discharge column, and a 16-ft. length added to the discharge vertically. The steam pipe was, at the same time, being disconnected at a union provided for that purpose just at the top of the shaft, and a new 16-ft. length screwed on. While this was being done on top, another gang of men, stationed on the pump to prevent twisting in lowering, had hauled in the slides mentioned above. All being now ready for a shift, the engineer lowered the pump slowly, and the men stationed at the discharge and steam pipe ropes allowed these pipes to descend with the pump, until the top of the newly added section of steam pipe was just opposite the union; all ropes were at once secured, connection made with the boiler, and the upper discharge elbow and its pipe again bolted in place, the men on the pump adjusted and secured the slides, and all was once more in position, ready to pump out another 16 ft. of the shaft. After the men became expert in their several duties the time required to make shift was about 25 minutes, computing from the stoppage of the pump to the starting again.

But simple as the above may appear, it was only after repeated trials and failures, and considerable experimenting, that the wished for result was attained. At the east shaft we reached the tunnel grade with our suction pipe 166 ft. below the top five several times before we could stay there long enough to pump out the 500 lineal feet of tunnel already driven. It should be remembered that the plunger, as we called it, was only an emergency pump intended to empty the shaft and tunnel preparatory to setting up a large permanent pump of the horizontal type in the tunnel. The vertical pump was troublesome to handle, took up much room with its ropes and pipes, and was difficult to pack.

The steam connection was the most troublesome feature. When the pump was in action there was a very remarkable vertical motion due to the elasticity of the fall ropes. This was especially the case when we neared the bottom of the shaft, and a rigid connection was consequently impossible. After trying a jointed steam pipe without success, we made use of a 6-ply gum and canvas steam hose, 6 ft. long, placed between the steam pipe and the steam cylinder on the pump, but, under the steam pressure carried, 100 lbs. at the boiler, this hose burst in a few hours; 10-ply canvas and pure gum was next tried, but even this would sometimes fail by the intense heat softening the gum and thus allowing the hose to blow off of the iron nipples in the end, in spite of grooves and broad iron clamps, intended to prevent any such accident.

The radiation from the steam pipes, and the ascending steam, caused by water falling on the hot cylinder and pipes, made the temperature in the shaft almost unbearable. This, and the entire want of ventilation in the deep and narrow hole, caused great physical suffering among the men whose duties called them inside, especially when this experience was varied by the bursting of a 2-in. steam hose in the face of the pumpman. To the pluck and endurance of these faithful workmen all success was really due. This 166 ft. of shaft was finally pumped out in a little less than nine hours. Having, we hope, given a sufficiently detailed description of how we got into a scrape at the west shaft, and how we finally got out of it, we can now look back and see where we made our mistakes.

First of all, it should have been taken as granted that water was to be met with in abundance, under the circumstances, as we neared the rock. All indications to the contrary, obtained from borings, should have been disregarded. Had this been done, in the opinion of the writer, it would have been ill-advised to have used any form of compound shaft, partly wood and partly iron. The iron cylinders should have been continued to the rock, by using iron rings of reduced height, and cut into four or more segments, put into place at the bottom of the shaft, as soon as the friction prevented the further descent of solid cylinder sections and the surface water was excluded. The advantages would have been many as compared with the attempt to hang a square wooden shaft to an iron cylinder, the vertical connection would have been continuous and abundantly strong, and the entire shaft could have been made water-tight by caulking the joints with dry pine wedges, or otherwise. And with rings not more than 21½ ft. in height any soft ground could have been passed by a proper system of poling.

It is true that some hanging appliance similar to finally that used might have been at first put into a timber shaft had the possibility of meeting water been fully considered by all parties concerned, but the experiment, we think, would have been a dangerous one as compared with a continuous iron cylinder, and, all things considered, it would not have been as economical as iron.

NOTE.—The Dorchester Bay Tunnel was commenced in January, 1880, and at this date some 4,600 feet of the tunnel are driven. The contract was let to Mr. R. A. Malone, of Pennsylvania; the writer was engineer for the contractor.

We cannot, in justice, omit the mention of our personal indebtedness to Michael Nolan, who superintended the retimbering of the west shaft, and to William Reardon, the rigger, who put into place our hanging-up appliances. To the pluck, endurance and practical knowledge of these two men very much of the success was due.

ENGINEERS' SOCIETIES.

THE INSTITUTION OF CIVIL ENGINEERS.

The 63d Annual Meeting was held on the 20th ult. From the Annual Report we quote as follows: "It had been pointed out by Thomas Tredgold in 1828, when requested to define the nature and objects of civil engineering, that the domain of the civil engineer would extend with every discovery of science. A comparison of the papers contributed thirty years ago with those of the present day bore out this opinion, as it showed the great changes brought about in the interval in the practice of the profession by the new industrial application of science. Having regard to the increasing number of subjects which occupied the attention of the engineers, it was manifestly important that the papers read at the meetings of the Institution and selected for publication should be so varied as to be useful to its members in whatever branch of the profession they might be engaged. The tendency of modern manufacturing process was to rely more and more upon machinery, the design and construction of which, as it became more elaborate, could no longer be the work of the mere handicraftsman, but called forth the highest powers of the skilled engineer. It thus happened that men were now to be found exercising engineering vocations widely different from those of the designers of roads, bridges and similar public works, who, very erroneously, had often alone been recognized as civil engineers. As the Institution was largely composed of the former class, it was necessary that the range of subjects for papers should be widened, so that all interests might be consulted. The council appealed to the four volumes of Minutes of Proceedings issued since the last annual meeting, as evidence of the success that has been attained in this direction.

The subject matter index to the whole of the publications of the Institution from 1837 to 1879 inclusive, which had been issued in the autumn, might be said to mark an epoch in engineering literature. The approval with which it had been received was evidence that the unobtrusive but painstaking labor of the compilers was fully appreciated. A name index, which would be a complement to the other, was in course of preparation.

During the past year there had been an increase of 52 members, 19 associate members, and 49 students, with a decrease of 6 associates, while the honorary members remained the same. There were on the books on Nov. 30 last 18 honorary members, 1,261 members, 1,406 associate members, 522 associates and 622 students; together, 3,899. At the same date in 1860 the number of members of all classes was exactly 1,000. The student class had only been created fourteen years. In the interval 1462 candidates had been admitted, of whom 400 had since been elected into the corporation and 400 had ceased to belong to the Institution and in most instances to the profession. The deceases had been at the rate of nearly 19 per 1000, and had included several very old members, notably Mr. James Ashwell, the survivor of the five founders of the Institution.

The income last year was £12,398 11s. 5d., besides which the receipts had included £3,076 14s. on account of admission fees and life compositions (which were rigidly treated as capital, and were not used for defraying ordinary expenses), and £431 5s. 6d. from dividends on trust funds. The general expenditure had amounted to £12,093 7s. 11d., including £6,523 17s. 8d. for four volumes of Minutes of Proceedings and for the subject-matter index. A sum of £3,000 had been invested, and £390 0s. 1d. had been expended for premiums and prizes under trust. The cash balance in hand was £771 12s. 1d., being £424 2s. 11d. above what it was at the same period in 1880. The income had been nearly 4 per cent., and the total receipts 6 per cent. in excess of the previous year.

The following gentlemen were duly elected to serve on the Council for the ensuing year: Sir W. G. Armstrong, C. B., President; Mr. J. Brunlees, Sir J. W. Bazalgette, C. B., Sir Frederick Bramwell and Mr. E. Woods, Vice-Presidents; Mr. B. Baker, Mr. G. Berkley, Mr. G. B. Bruce, Sir John Coode, Mr. E. A. Cowper, Mr. J. N. Douglass, Mr. A. Giles, Mr. H. Hayter, Dr. W. Pole, Mr. Rawlinson, C. B., Mr. A. M. Rendel, Dr. C. W. Siemens, Mr. D. Stevenson, Sir William Thomson and Sir S. Whitworth, Bart., other members of Council.

WESTERN SOCIETY OF ENGINEERS.

At the annual meeting of the Society on the 3d, the following officers were elected for the ensuing year: President, W. S. Baker; First Vice-President, D. C. Cregier; Second Vice-President, K. F. Booth; Secretary, L. P. Morehouse; Treasurer, Charles Fitzsimmons; Librarian, John W. Weston; Trustee for three years, W. S. MacHarg. The annual report of the Secretary showed an increased membership and encouraging interest in the Society. A paper was read, and some minor business was transacted.

POLYTECHNIC ASSOCIATION.

At the regular meeting of the Association held Thursday evening, Jan. 5, Thomas D. Stetson, Esq., presiding, Mr. John Banvard read a paper on common lime mortar and hydraulic cement. He remarked that English authorities, with more patriotism than truth, state that hydraulic cement was first made in that country in 1796, giving the impression that the properties of such limes had never been known and made available. The fact is, on the contrary, that they had been known in Italy certainly as early as Vitruvius. Any good lime, with a proper quantity of clay, intimately combined, would make such cement. The best of all is made by finely grinding broken bricks or finer articles of pottery, and thoroughly incorporating the previously burned clay with the lime mortar.

The proportion of the constituents in the mortar in the great Pyramid of Cheops, the oldest building known, is two of sand to one of lime. Many commend the same proportions now, but the sand may be increased to four of sand to one of lime without injuring the strength of the mortar. Mr. Banvard had made good work with a mortar having as high a proportion as twelve to one, but beyond that it could not be trusted.

ARCHITECTS' DESIGNS.—The City Council of Indianapolis will pay as follows for designs for the new City Hall, the cost of which is limited to $150,000: Four hundred ($400) for the first best plan, two hundred and fifty dollars ($250) for the second, and one hundred and fifty dollars ($150) for the third; and when built, should the city decide to build by such plan, the architect whose plans were accepted and received the first award, shall enter into a contract that his compensation shall not exceed three per cent. for all plans, details, specifications and supervising of the erection of said building, and from this amount shall be deducted four hundred dollars ($400) awarded as first premium when his plans were accepted. That three plans receiving the premiums shall be the property of the city and left in the care of the Market House and City Hall Commissioners.

ENGINEERING NEWS.

GEO. H. FROST.....PROPRIETOR.

Tribune Building. New York City.

JULIUS W. ADAMS, *Past President A. S. C. E.*, EDITOR.

B. D. V. BURR.....ASSOCIATE EDITOR.

SATURDAY, JAN. 14, 1882.

EDITORIAL ANNOUNCEMENTS.

Terms of Subscription.—To the United States, Canada and the Sandwich Islands, $4 per annum, including postage; all parts of Europe, $5, payable in advance. Remittances at the risk of the subscriber, unless made by registered letter or by draft, check or P. O. order, payable to GEO. H. FROST.

Terms of Advertising.—One inch, 12 lines, one insertion, $2; one month, $6.50; three months, $17; six months, $30; one year, $50. Special rate for large space and long time will be given on application. Advertisements inserted for less than three months, payable in advance; for longer time, payable quarterly.

Articles for Publication in the current number should be received at the office of publication not later than Thursday morning, and advertisements not later than Friday noon.

Correspondence upon subjects which naturally belongs to the province of this journal is solicited.

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NOTICE OF MEETINGS.

The annual meeting of the Association of Civil Engineers and Surveyors of Michigan is in session this week at Lansing, Mich.

AMERICAN ASSOCIATION OF MECHANICAL ENGINEERS.—A regular meeting of this society is announced to be held in Philadelphia, beginning Wednesday, April 13. Members are requested to send their papers to the Secretary in ample time for reference to the Committee on Publication. There will be debate upon papers presented in 1881 before any new papers are read, and members wishing to discuss such papers are asked to study them before the meeting. The last meeting of the Council to pass upon application for membership will be at least 20 days before the meeting.

AMERICAN INSTITUTE OF MINING ENGINEERS.—The annual meeting will be held in Washington, D. C., beginning Tuesday, Feb. 21, 1882. Members are requested to give early notice to the Secretary of their intention to read papers at this meeting.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—The annual meeting will be held at the house of the Society, 127 East 23d street, New York, beginning Wednesday, Jan. 18, 1882, at 10 a. m.

The annual reports will be presented; officers of the society elected; proposed amendments to the constitution discussed. Reports are expected from the standing committees on gauging of streams, on tests of cement and on preservation of timber; also a report from the Board of Direction on the subject of tests of American iron, steel and other metals. These reports will be discussed.

Lunch will be served on Wednesday at the house of the Society. An evening session will be held if found desirable.

Thursday, Jan. 19.—Visits will be made to engineering works, among which will be the works of the Manhattan Gas Co., the Hudson River tunnel, the New York Steam Co., the New York and Brooklyn bridge. On the evening of Thursday there will be a reception and supper.

Details for the meeting, arranged by a special committee, will be announced at the opening reception.

Members intending to be present who have not already so notified the Secretary are requested to do so at once, that proper provision may be made for the full number.

JOHN BOGART, Secretary.

THE POLYTECHNIC ASSOCIATION.—Meets Thursday evenings from September to June, room 24, Cooper Union Building, New York City.

New inventions and miscellaneous subjects, 7.30 to 8.30; paper or address till 9; discussion thereon till 9.30.

EAST RIVER BRIDGE.

The completion of this important work is looked forward to as an event in American engineering; and the unaccountable delay which has prevented this completion, when it seemed all but on the point of achievement, has very naturally excited attention and elicited comments of all kinds—some, not complimentary to the engineers of the work, and others equally complimentary to the Board of Trustees, upon whom very properly rests the responsibility for the work. It is known that a stated meeting of this board took place on Monday last (9th inst.), at which it was supposed, from the tenor of the discussions and resolutions adopted at the previous meeting, held Dec. 15, that important information would be forthcoming; and upon this supposition, the readers of ENGINEERING NEWS were requested to suspend their opinions for or against the management, in view of the new light which we had every reason to suppose, would be shed upon the past transactions, both of trustees and engineers. Hence, in accordance with our avowed mission of supplying engineering news, we are constrained to notice this meeting of the trustees, though, truth to say, the proceedings furnish no enlightenment on the causes of the delay in the work, nor as to *who* in the past had both the wisdom and audacity to so shape matters that the bridge when completed should not be a mere highway between two sections of the same city, but should as well become a factor towards the material progress of a—we were about to say—wide stretch of country, but will be better understood, if we say Long stretch of country. Nor do we find in these same proceedings any definite statement as to when this most desirable consummation will be effected. It is true that in answer to a question by the Mayor of the city of Brooklyn, as to "*when* the Bridge would be completed," he was told by the President, "Next fall"; but this, under the circumstances, cannot be taken as a very definite answer, it being well known that so long ago as May, 1878, it was stated that "twelve months would be ample time within which to complete the structure," and we ourselves, with the best light attainable by an outsider, had accepted as satisfactory the statement, made some ten months since by one who was in a situation to *know*, that the bridge would be open for travel in this month of January, 1882!

It seems in the spring of 1878, when the Board of Trustees considered the early completion of the bridge as being then assured, a committee of the trustees was appointed to examine and report "upon the use to which the roadway of the bridge should be devoted." This was when the question of rapid transit in Brooklyn was under advisement by a commission appointed by the Mayor of the city, under the so-called rapid transit act, and it being understood then that, in view of the exposure of the cars to the effects of high winds, the chief engineer had been in favor of a gauge of track of six feet over the bridge, thus precluding the passage over the bridge of any motors or cars of the ordinary width of track in use in this section of country. The committee, very wisely, it is thought, reported decidedly in favor of the ordinary 4 ft. 8½-in. gauge of track, and gave their reasons therefor in full; but aside from using the expression, "that in the event of a 6-ft. width of track being adopted, no other cars than those in use by the Bridge Co. could be taken across," they do not refer in any way to the kind of traffic to be anticipated, but close their report in the following words: "The question of the use of the roadway will still be open and largely under the control of the trustees," and offered the following resolutions, which were adopted:

Resolved, That the gauge of the railroad designed for railway transit should be fixed at 4 ft. 8½ in.

Resolved, That it be held practicable to transfer (transport or carry over) the kind of car known as the Palace or sleeping car upon the bridge under the conditions already stated, and so that the stress of the car may be distributed over two or more beams; provided that no train should consist of a greater number of cars than three."

The adoption of these resolutions justified (in their own minds), some individual or individuals members of the Board of Trustees, of course, in authorizing the engineer to make such change in the height of trusses as would permit such passage of these cars, although it would appear that no direct vote to that effect was taken by the Board. This change necessitated an increase in the weight of superstructure, and when it was found that a largely increased cost of the bridge was, or would be, the result, no one has been found to accept the responsibility of having authorized it; but the measure was a wise one, although reached in an irregular manner, and as the change has been virtually effected, and the strength of the cables is sufficient, as the engineer expresses it, "to pull up the anchorages," the trustees, if wise, will abandon the attempt to find out *who* authorized the change of plan, and devote themselves to the completion of the work—a matter of far more importance to the public. But measures to this end formed no part of their deliberations. The engineer, in a detailed statement, having shown that precisely 1,064 tons more of steel was required, instead of the 1,200 tons previously supposed, one of the trustees offered a resolution, which was carried, "That the Chief Engineer be asked to inform the Board how the reduction of 136 tons from the 1,200 extra tons called for was made?" One would suppose, that after all the vexatious wrangle growing out of an increased quantity of material being called for, the fact that a less amount would suffice might be somewhat satisfactory, but it would seem not to be so. The Board adjourned at this stage of the proceedings, and we must wait a few weeks before the anxious public can know why 136 tons more of steel is *not* wanted, and after that important piece of information is made public—if, in the meantime the engineer should not have succeeded in economizing a few more tons of steel, which would call for another detailed report, this Board of Trustees might recollect, possibly, that there is something of more importance just now to the public; and that is, to show that the committee have grossly mismanaged the work committed to their trust.

That there has been mismanagement is too evident; not in the sense that money has been squandered, or that any individual connected with the management has profited in any manner by this long delay to complete the superstructure. No one supposes this; the character of the individual members comprising the management forbids the supposition. But that the Board of Trustees entered into contract for the material of the superstructure, without proper guarantees for its fulfilment, is too apparent to admit of question. Whatever may be the causes of the delay to complete the superstructure, in the difficulties attending the production of novel shapes of a comparatively new material, if they did not admit of close estimation, there should have been such judgment shown as to have provided for this contingency in the framing of the contract for the material of the superstructure. The public have not been advised of the cause of delay which has added over a twelve-month at least to the opening of the bridge for travel, and it is evident that whatever may have been the cause, it is still potent in rendering it, in a measure, very doubtful when this day will arrive.

The public were led to expect that the bridge would be completed by the 4th of July, 1881, at the farthest. Now the President says "that if no financial complication arises it will be completed by next fall!" Setting aside all unprofitable inquiry as to who did this or that, the young Mayor of Brooklyn showed his practical common sense as follows: Mayor Low said he had a question or two which he would like to ask. The history of the bridge was interesting and important, *but the steps to be taken for its rapid completion were of more importance and interest to the city.* He would like to know if 1,000 tons or a little more would be enough to complete the work.

Mr. Barnes again explained the matter of the quantity needed. The engineers said now that 1,064 tons would be sufficient. The price was 8¼ cents per pound.

Mayor Low—Do the engineers commit their professional reputations to the statement that the amount called for will be sufficient to complete the work?

Mr. Murphy—I so understand it.

Mayor Low—When will this amount be delivered?

Mr. Murphy—Probably by May next, if no financial complication arises.

Mayor Low—If the money question is not in issue, when will the structure be completed?

Mr. Murphy—If the money question is not in the way, the bridge will be completed by next fall.

Mayor Low—Is the money question in the way?

Mr. Murphy—We shall need about $600,000 more to complete the work and to put in the improvements in the way of facilities for transportation and traffic which are deemed advisable.

Mayor Low said he thought a report should be made of the amount needed, what it is needed for, the time when the work would be completed, and the contingencies which were to be expected.

Mr. Murphy asked if he wished to put the matter in the form of a motion.

Mayor Low said he did not, but only desired to make the suggestion.

It does not appear by the report of proceedings that this suggestion was embodied in any resolution of the Board; it was far too practical to admit of their immediate appreciation of its importance, and the Board adjourned without further action in the premises.

We append, as a matter of interest, the report of the Chief Engineer read at this meeting:

BROOKLYN, Jan. 9, 1882.

Hon. Henry C. Murphy, President Board of Trustees New York and Brooklyn Bridge:

DEAR SIR: I beg to submit the following in reply to

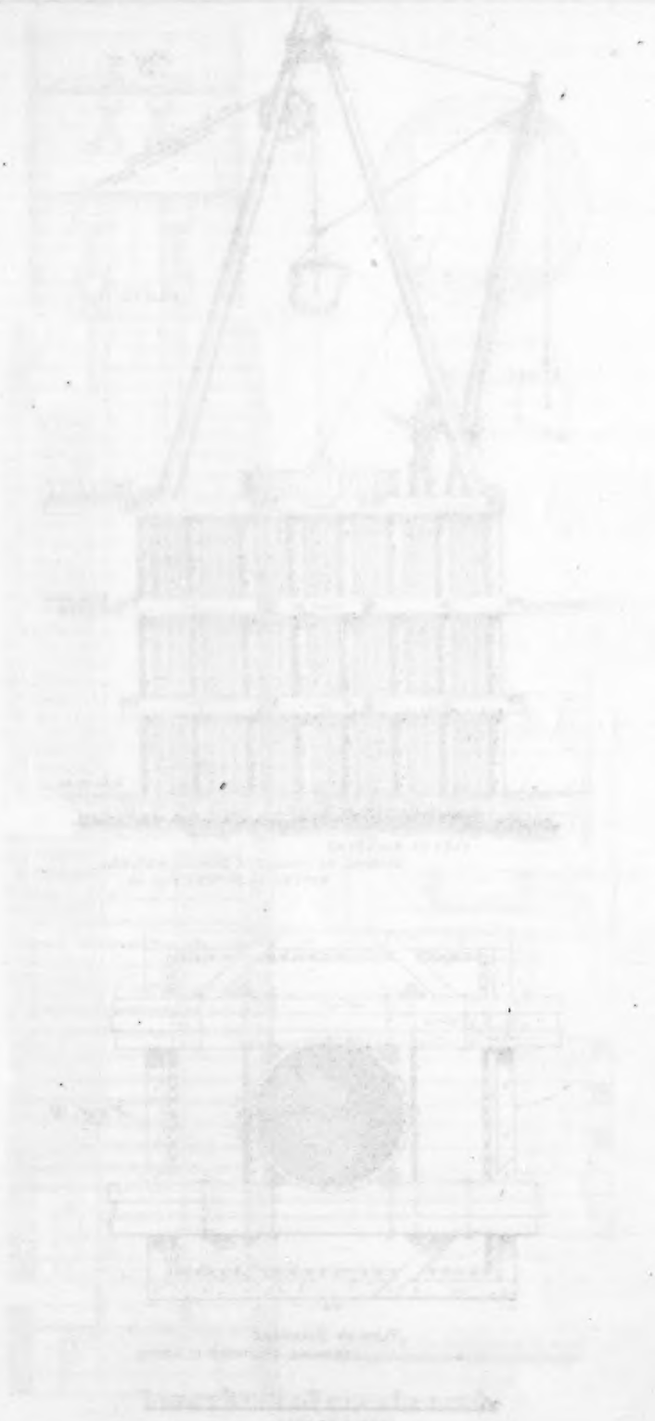
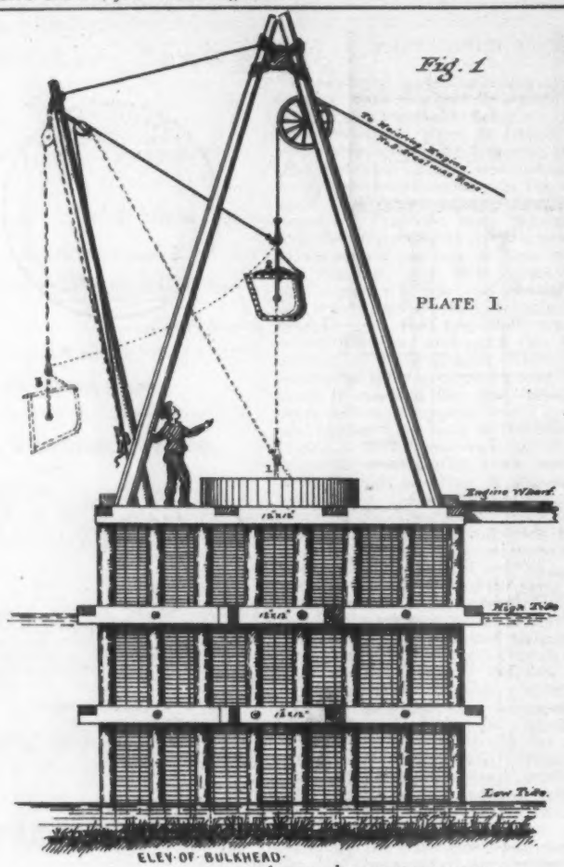


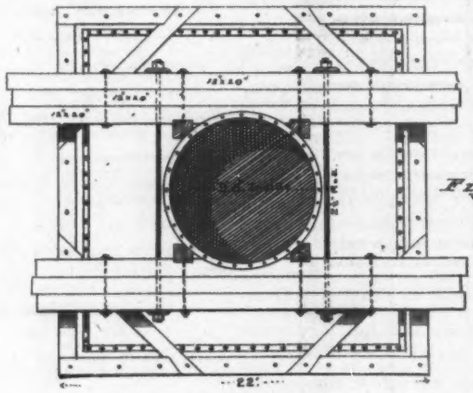
PLATE I.

Fig. 1

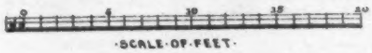


ELEV. OF BULKHEAD
SHOWING "OUT-HAUL" FOR DUMPING MATERIAL
BEFORE CAGE WAS PUT IN

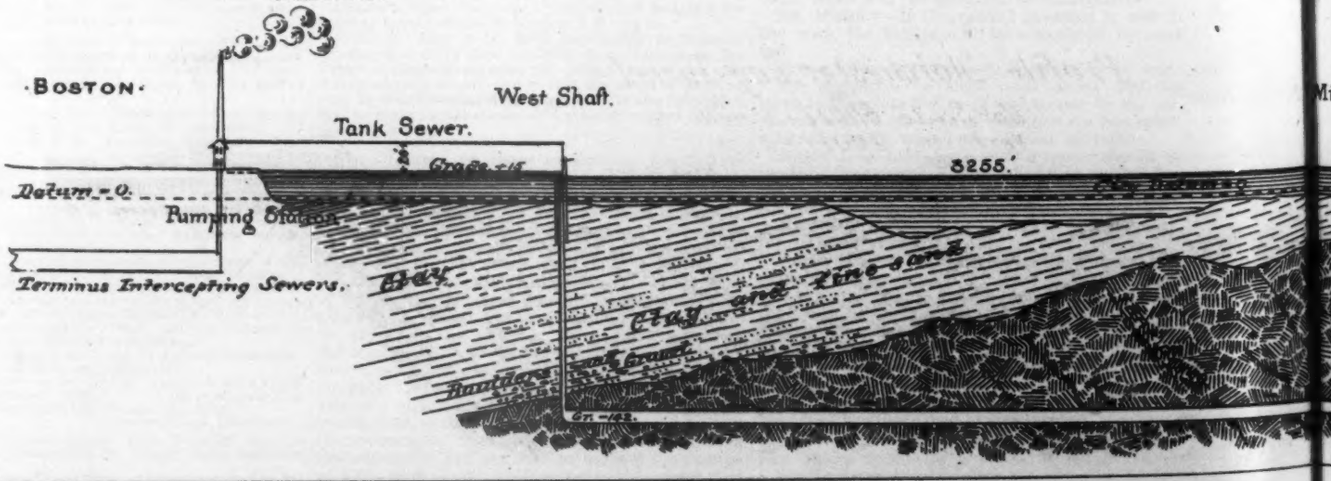
Fig. 2.



PLAN OF BULKHEAD
SHOWING CYLINDER CLAMPS



SCALE OF FEET



SHAFT SINKING UNDE[R] DI
DORCHESTER BA[Y] T
BOSTON, M[ASS.]

By D. McN. S[TUE]
Member A. S. C[E.]

DIFFICULTIES AT

TUNNEL,

ASS.

UFFER.

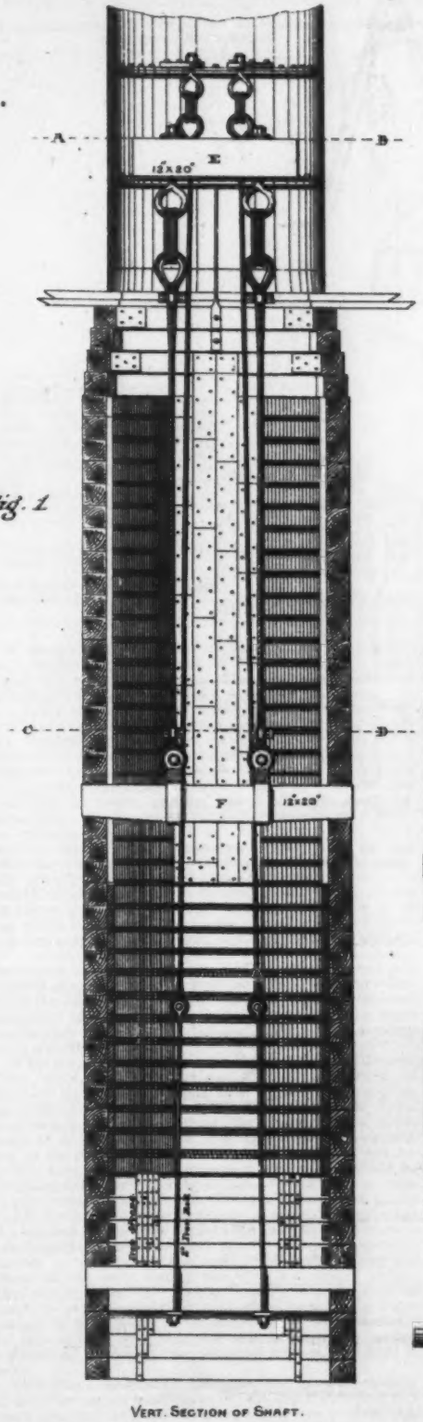
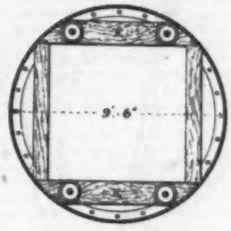


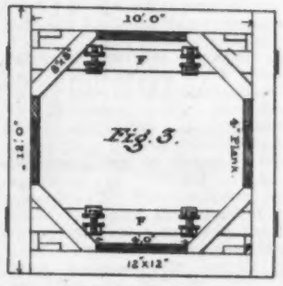
Fig. 1



SECTION ON A.B.

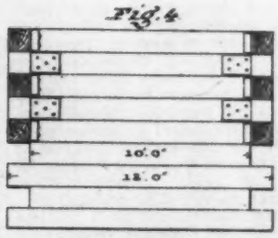
Fig. 2.

PLATE II.



SECTION ON C.D.

Fig. 4



SHAFT FRAMING.

SCALE OF FEET.

VERT. SECTION OF SHAFT.

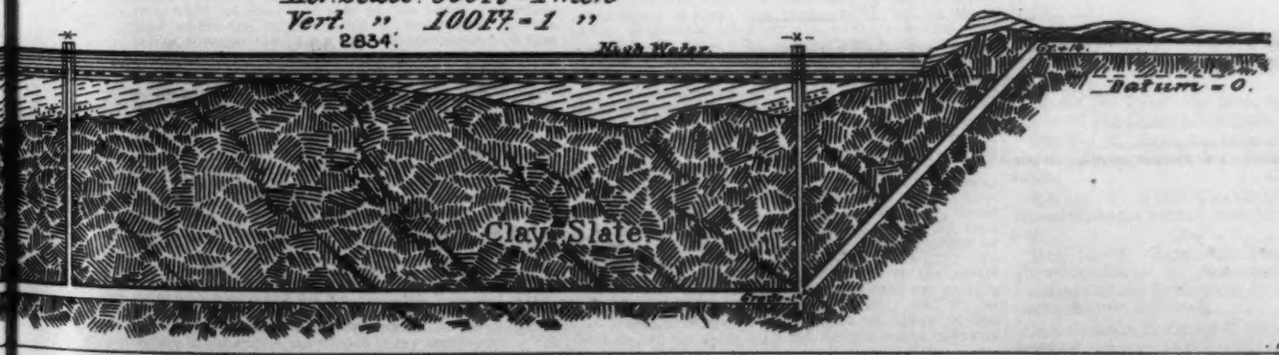
·SQUANTUM·

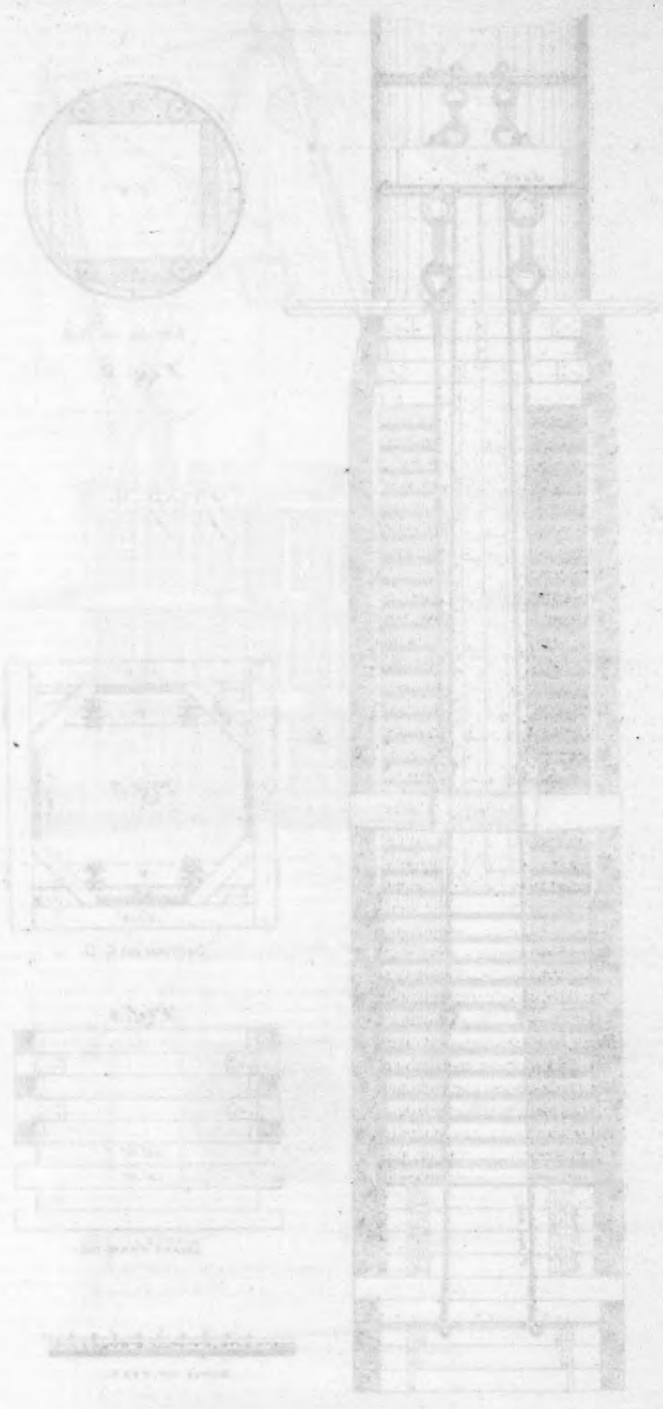
Profile Dorchester Bay Tunnel.

Middle Shaft.

East Shaft.

Hor. Scale. 600 Ft - 1 inch
Vert. " 100 Ft - 1 "





the resolutions passed by the Board of Trustees at the meeting held Dec. 12, 1881:

The aggregate strength of the wire composing each of the four cables has been estimated to be 12,300 tons (of 2,000 lbs.), and the elastic limit two-thirds of that amount, namely, 8,200 tons.

These estimates have been based upon the following data: An average has been made of the results of a large number of the tests of the pieces cut from the ends of each wire of which the cables were made.

This averaging embraced about one-third of all the wire in the cables, and when applied to the full amount in each cable gave the result above stated.

Most of the tests were made very soon after the wire was drawn and galvanized. Subsequent tests showed that the wire gained in strength by lying, at least, while these tests also showed that the wire was most likely to show inferiority at the ends, where, of course, all of the ordinary tests were made.

These facts seemed to justify the assumption that the average strength of all the wire was not placed too high.

Numerous tests showed the limit of elasticity to be never less than two-thirds of the ultimate strength and usually considerably more, while that which had the highest limit of elasticity usually had the higher modulus. Thus it will appear that the very lowest probable elastic strength of the cables has been stated, at which not a single wire coming within the requirements will be likely to have exceeded its elastic limit.

The method of splicing the wires was such that the full strength of the wire was maintained at all the joints.

The regulating of the wires and strands was so accurately done as to show almost exact parallelism when finally brought together in the cable.

The wires varied considerably in size, hence each piece tested was carefully measured and its area of cross-section obtained.

	Lbs.
Amount of wire in cables	6,928,346
Amount of wire in one cable	1,732,086
Solid section of each cable	144,834
At 170,000 per square foot	24,921,780

STRENGTH OF SUPERSTRUCTURE.

The superstructure consists essentially of the floor system and stiffening trusses.

THE STRENGTH OF THE FLOOR BEAMS.

For the strength of the floor beams and the concentrated transitory load it is designed to sustain, I would refer to the sketch appended hereto.

The trusses have been so proportioned that when one-half the bridge is loaded it would deflect 10 in. at a point 400 ft. out from the tower, whereas without trusses and stays the cables alone would deflect 3 ft. at that point under the same load.

One of the most serious difficulties to be contended with in this structure is the maintenance of the balance of spans, arising from the exceptional length of the land spans. One of the early designs of this bridge contemplated the anchoring down the land cables half way between the towers and the main anchorage. This would apply to the case when the main span was loaded and the land spans empty. The reverse case when the main span was empty and the land span loaded could evidently not be provided for by those means. A closer examination also showed that after making proper allowances for temperature, stretch and rise and fall of land cables, such a provision would not be as effective as might be supposed at first sight. In most suspension bridges with short land spans the saddle movements are soon checked by the rapidly incurring tensions in the land cables as their curve becomes straightened. With our very long land cables other means must be added to check excessive saddle motion. There are three in number: Friction of saddle rollers, resistance and support of the truss and action of the stays.

The friction of the rollers under the saddles is as yet quite small, and the sensitiveness of the saddles due to the unequal loading of one or the other spans, has, during the erection of the superstructure been quite marked. The friction will increase with the load and with time, and I believe the saddle movement in the completed work under the ordinary traffic will be very small indeed.

The trusses counteract chiefly by the resistance they offer to being bent upward and also by relieving the cable of a part of its load, because they are continuous through the towers.

The stays, however, afford the most effective means of checking saddle motion. They act in a double capacity. As soon as a saddle movement causes the cable to fall it transfers a portion of its load to the stays, which extend out three hundred and fifty (350) feet, while on the other side of the tower the whole load which the stays carried is transferred to the cables, thereby increasing their counter tension on that side.

I am aware that the stays do not act in perfect harmony with the cables in cases of extreme temperature, and for a single span I should not be disposed to advocate their use, yet in our case I consider them indispensable. We need all the support they will give, and when the cable is depressed under a full load they will always come into bearing at a time when we want them most. The above-mentioned want of harmony between stays and cables is less in reality than in theory, because in a curve of equilibrium it takes a very small increase or diminution of load to lower or raise it in the quarters sufficient to bring the other system into action.

The weight of the suspended superstructure, when completed and ready for use, together with the transitory or line load, is shown in the following tabular statement. With these weights was calculated the margin of safety in the cables, mentioned in my last report. The statement also shows what proportion is carried by the cables and how much by the stays and trusses.

TABULAR STATEMENT OF WEIGHT OF SUSPENDED SUPERSTRUCTURE AND TRANSIENT LOAD.

	Total weight of bridge, anchorage to anchorage, 3,400 feet—tons.	Weight of main span between the first suspenders, 1,345 feet—tons.	Weight of main span carried by the cables and long stays between suspenders 18 and 18, 1,297 feet—tons.	Weight carried by the trusses and short stays between 1st and 18th suspenders, 248 feet—tons.
Suspended superstructure	6,620	3,050	2,340	710
Suspenders, wrought and cast-iron cable bands, over and under floor stays, wire netting and railing, propelling rope and supporting sheaves, grate bars, cable cross connections, etc.	1 180	560	560	.....
Cables	3,460	1,000	1,580	.....
Timber flooring	2,760	1,230	1 030	300
Steel rails, tramway guard rails and other iron in floor	600	300	250	50
Total permanent weight of bridge	14,680	6,740	5 700	960
Transitory load	3,100	1,380	1,160	220
Total weight of bridge, including transitory load	17,780	8,120	6,920	1,180

A change as important as the raising of a truss is not made at random on the spur of the moment. It is the result of a process of thought extending over weeks and months, and requires a more extended explanation.

It being the wish of the Board, as shown by the resolution annexed to the report of the committee, of which Mr. Kinsella was chairman, on the 6th of May, 1878, that the bridge should be adequate to the passage of a Pullman car, it became incumbent upon me to provide the necessary truss power, with which to transfer the concentrated loads, and to check the increased deformation of the cables resulting therefrom. Now, to increase the strength of the truss, we either have to increase the dimensions of all its parts, or else raise the truss and keep its dimensions about the same. The outer trusses could not have been raised, because it would have been necessary to strengthen the top chords by heavy and unsightly cross bracing extending over the whole roadway. They were therefore left at their original height, with a slight addition to their weight. I am aware that, theoretically, all the trusses should have been of the same height, but these outer ones are located at the extreme ends of the floor beams, far away from the other trusses and from the location of the concentrated loads, so that by a slight flexure of the floor beams they will be able to act sufficiently in harmony with the other trusses.

With the four middle trusses the case was different. They were close together and had to take care of heavier and more concentrated loads. In the plan, as it stood from 1869 to 1878, the promenade truss was raised 4 ft. higher than the intermediate truss next to it. The object of this was to serve as a railing to the promenade. For the two trusses to act together they must be of the same height. This could be attained either by lowering the promenade truss or raising the intermediate truss. To have lowered the promenade truss would have weakened it, which was not what we wanted. I therefore raised the intermediate truss to the height of the other and put in a cross connection on top to steady the top cord. An examination was made at the same time to see what increase of weight this would involve. It was found that, on paper at least, it would amount to very little, because the extra weight of post could be balanced by a slight decrease in the section of cords and tension bars. In actual execution, however, one hundred tons were added to each.

This plan remained in this state for several months. It afforded ample head room for the small elevated railroad cars and their locomotives, but it was evident that if the cars of other railroads, including Pullman cars, should ever apply for transit across the bridge they could not be accommodated.

Of course, I objected earnestly for two reasons: One because I could not see any probability of the passage of the largest size of railroad cars, and the other because it was my duty to protect the structure against every ton of additional weight not absolutely necessary. When I consented to make this change it was not so much owing to personal solicitation as to the reflection "of what benefit has it been to erect this bridge at a vast expense, unless we use it for every possible purpose to which the structure will lend itself?"

It is great mistake to suppose the trusses are too heavy for the rest of the work. At least 500 tons more material would be required in the trusses of the main span to make them as strong as the rest of the floor system. Weight has been added to the whole structure, and not to the trusses alone.

Owing to the great strength of the cables the margin of safety is a very rigid figure. It takes several hundred tons to move it up or down perceptibly. Hence it is that an inch off the planking or a shaving here and there has so slight an effect on the margin of safety, and therein lies our greatest security. To illustrate this point let me state that if the entire moving load of 1,750 tons were doubled the margin would only be reduced from 4 to 3⅗, and if, on the other hand, 1,000 tons could be taken of the dead load of the main span the margin would only rise from 4 to 4⅕.

In order to illustrate how wholesale and radical any reduction of weight must be to affect the cables appreciably, I will merely mention three possible cases, although I do not advocate any of them.

If the elevated promenade were abandoned and the foot travel thrown on the roadways below them, each middle cable would be relieved of 400 tons of strain, or of 13 per cent. of their total strain, and their margin would rise half a point.

Or if the intermediate trusses could be omitted (except their bottom cords) each of the four cables would be relieved of 180 tons of strain or six per cent. of their total strain.

Or again, if the four middle trusses could be cut down to the height of the outer ones 108 tons of strain would be taken off each of the four cables, provided it were equally distributed, or 360 tons off each middle cable, or seven and one-half per cent. of total strain.

The cables are strong enough to pull up the anchorages. Very respectfully yours,

W. A. ROEBLING, Chief Engineer.

It was moved that the report be printed and copies sent to the members of the Board, and that it lie over until next meeting, when it should be brought up for discussion.

PERSONAL.

D. W. C. ROWLAND, the present General Superintendent of the Tennessee & Nashville Railroad Company, was born in Hartford, Conn., July 1, 1829. He began his railroad career in June, 1851, as a baggageman on the Mobile & Ohio Railroad, rapidly advancing to the position of passenger conductor, and thence to that of Master of Transportation. He was Assistant Superintendent of Military Roads during the war, and in 1864 and 1865 was General Superintendent of Adams Express Army Freight Line, at Louisville, Ky., until Nov. 1 of the latter year, when he accepted the office of Assistant Superintendent of the Louisville & Nashville Railroad. The road, at that time, main stem and branches, was about 300 miles in length, and just emerging from a four years' war, was in a state of disorganization, without system or discipline. But Mr. Rowland went to work and ably assisted Colonel Fink in reorganizing and systematizing the road, and for ten years, up to October, 1875, was the chief assistant of Colonel Fink, who cheerfully awards to Mr. Rowland great credit for the excellent system and discipline of the transportation department, as adopted by the Louisville & Nashville Railroad. During this period, the road had been increased in length from 300 miles in 1865, to 900 in 1875. Yet the supervision and direction of organizing and operating the transportation department were personally directed by Mr. Rowland, and twice during Mr. Fink's term of ten years Mr. Rowland was promoted, first to the position of Superintendent, and next, in 1872, to that of Assistant General Superintendent. The latter position he held up to October, 1875, when Col. Fink resigned, and Hon. E. D. Standiford was elected President, and who immediately appointed Mr. Rowland General Superintendent of Transportation, of which position he had full control and discharged the duties of, throughout the whole term of Dr. Standiford's administration.

In October, 1879, the organization was changed and Col. F. de Funiak was made General Manager, who also re-appointed Mr. Rowland to the position he had so ably filled. Within the past two years the road has been extended by lease and purchase to 1,840 miles, more than double its length of 900 miles in 1875, and six times its length in 1865; yet Mr. Rowland has grown steadily up with it, and has personally reorganized and systematized all the new acquisitions to the road in the transportation department, besides directing the general working of the same, and bringing them one and the same uniform rules alike on all portions of the system.

GEO. F. BREYMANN, of the firm of Thacher & Breymann, submarine divers and contractors, Toledo, O., was in the city this week. Mr. Breymann has been full of business during the past season, being chiefly employed in submarine work in water-works construction and in bridge foundations.

A. GOTTLIEB, President and Chief Engineer of the Keystone Bridge Company, Pittsburgh, was in the city this week on business connected with his company.

MR. A. R. TREW has been appointed Chief Engineer of the Canada Southern Railway.

MR. W. M. DALY has been appointed Chief Engineer of the Cincinnati, Selma & Mobile Railroad.

MR. B. F. HANCOX is Chief Engineer of the Massachusetts Central, with head-quarters in Boston.

MR. D. W. LUM has been appointed Engineer-in-charge of maintenance of ways and buildings of the Lexington division of the Chesapeake & Ohio Railroad.

MR. CASIMIR CONSTABLE, member A. S. C. E., was married on the 11th to Miss Jennie Constable, daughter of Mr. William Constable, President of

the Union Club, N. Y. City, at his residence in West Forty-eighth street. Rev. W. N. McVickar, of Philadelphia, assisted by the Rev. Dr. Robert S. Howland, rector of St. Bartholomew's, performed the ceremony.

D. W. CUNNINGHAM, Member A. S. C. E., formerly Assistant Engineer Boston Additional Water Supply, and more recently engineer for a system of sewerage of the city of Stillwater, Minn., has been appointed Engineer of the Water Board, Minneapolis, Minn., with headquarters in Room No. 1, City Hall.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

BY J. JAMES R. CROES, M. AM. SOC. C. E.

(*Continued from page 6.*)

CLXXIV—KEOKUK.

Keokuk, Iowa, in lat. 40° 25′ N., long. 14° 26′ W., is on the Mississippi River at the foot of the Des Moines rapids, which are 12 miles long, in which distance the river falls 24 ft. The town, which was founded in 1840, is on limestone bluffs 130 ft. above the river.

In 1877–8 water-works were built by a private corporation, after the plans of W. C. Stripe, C. E., taking the supply from the river and pumping directly into the mains by a Holly 4-cylinder steam engine with cylinders of 14½-in. diameter and pumps of 8-in. diameter, all of 22-in. stroke. There is also a Worthington compound engine of 1,500,000 gallons daily capacity.

The water is taken from mid-channel in the river and conveyed through a 20-in. cast-iron pipe to a filter 50 by 15 ft., built of brick laid in cement. The bottom is 6 ft. below low-water level. Four feet above the bottom is a floor of timber joists laid on edge and ¼ in. apart, on which is laid broken stone, charcoal, coarse and fine sand, to a depth of 2½ ft. The filter is fairly effective. The water is aerated in passing down the rapids, and surface drainage from the opposite bank of the river is intercepted by a canal built by the U. S. government on that side.

Distribution is by cast-iron pipe, of which 11⅛ miles are in use, of from 20 to 4-in. diameter, 4,500 ft. being less than 6 in. There are 76 fire hydrants and 5 fountains, for each of which the city pays $100 per year. There are 450 taps.

The population in 1880 was 12,117, and the daily consumption is 550,000 gallons.

The ordinary pressure maintained at the pumps is 90 lbs. per square inches, which gives 35 lbs. in the highest part of the city. The fire pressure is sometimes 190 lbs. at the pumps.

The cost of the works has been $102,000. No returns are given of revenue and cost of maintenance. W. C. Stripe has been the engineer and manager of the works since their beginning.

CLXXV, OMAHA.

Omaha, Nebraska, in lat. 41° 15′ N., long. 95° 57′ W., is on the west bank of the Missouri River on three terraces, the first a few feet above high-water mark, and from 700 to 1,000 ft. wide; the second from 17 to 70 ft. above high water, and from 1,000 to 7,000 ft. wide, and the third of undulating surface, rising in places to 250 ft. above high water. The town was founded in 1855.

Water-works were built by a private company in 1880–81 after the plans of J. D. Cook, C. E., Chester B. Davis, C. E., being chief engineer of construction.

The supply is taken from the Missouri River more than a mile above the main outfall sewer of the city, and is first lifted by steam pumps into three settling basins, of slightly different dimensions, but averaging 325 by 125 ft. and 10 ft. deep, with inside slopes of 2 to 1, lined with brick laid in cement. They are used alternately. The time required for deposition of the sediment varies from 10 hours to 40 hours.

From them the water passes to the clear-water basin, 430 by 45 ft. and 10 ft. deep, whence it is lifted 280 ft. by two Knowles pumps to a reservoir 2 miles N. W. of the city, built in excavation and embankment, with two divisions, each 199 by 240 at water surface and 24 ft. deep, lined with 1 ft. of clay puddle, covered on the slopes with brick laid dry on edge, and on the bottom with 6 in. of broken stone.

The main engine is a compound-condensing Knowles pumping-engine, with steam cylinders of 33 and 60-in. and pump of 24-in. diameter, all of 42-in. stroke. The auxiliary engine is a high-pressure one, with 38-in. steam and 19-in. water cylinder, of 36-in. stroke.

The pumping main to the reservoir is of 16-in. diameter for a portion of the distance, then enlarged to 20 in. and again to 24 in. It serves also as the supply main from the reservoir.

Distribution is by cast-iron pipe, of from 18 to 4-in. diameter; 32 miles are laid, with 255 fire hydrants, 328 gates and 700 taps.

The works first went into operation in September, 1881, and the daily consumption is now about 350,000 gallons. The population in 1880 was 30,518.

The capital stock of the company is $600,000. The works have cost $400,000.

Nathan Shelton is Secretary and Treasurer of the company.

The receipt of statistics as follows is acknowledged with thanks: From Chester B. Davis, Chief Engineer, statistics of Omaha (Neb.) water-works. From D. Feller, Superintendent, reports of Water Commissioners of Binghamton, N. Y., for years 1876, 1878, 1879, 1880. From John Whitelaw, Chief Engineer, 25th report of Cleveland water-works for Dec. 31, 1880. From W. C. Stripe, Chief Engineer and Superintendent, statistics and water rates of Keokuk (Iowa) water-works.

CORRESPONDENCE.

LAKE SUPERIOR ENGINEERING.

TO ENGINEERING NEWS:

Assistant (admiring a one-foot grade on a profile after running through a ravine): Mr. ——, that is a very nice grade and better than I expected could be gotten.

Chief: Oh, well, that is hardly enough to push the cars along; make it two feet to the hundred.

Assistant: All right.

Yours truly,

[Communicated.] B.

THE STANDARD METRIC CHAIN.

OFFICE OF THE MEXICAN CENTRAL RAILWAY,
GUANAJUATO, Mexico, Dec. 23, 1881.

EDITOR ENGINEERING NEWS:

Quite a diversity of opinion exists among some engineering acquaintances of mine as to what should be the standard length of a metric chain. Some claim it should be 20 meters, and others insist on 25 meters. Now this is a matter of importance, especially since the metric system is making such headway in civilized countries.

Some length ought to be adopted in order that one uniform series of tables could be calculated, to be used invariably hereafter as the metric standard. I would suggest that parties interested in this matter give their relative views through the columns of your valuable paper, or it might be advisable to appoint a committee of three or five persons to report on this subject, and I take the liberty of mentioning the name of Mr. Frederick Brooks, C. E., as one of them.

Yours respectfully, EMILE LOW.

WHAT IS GRADING?

PITTSBURGH, Pa., Jan. 8, 1882.

EDITOR ENGINEERING NEWS:

You ask for opinions upon the technical meaning of the word grading. The geological term degradation and the engineering term graduation or grading have the same derivation and nearly the same meaning. The first is the natural and accidental excavation of earth and rock from higher levels with the corresponding filling up of lower levels; the second is the same operation performed artificially and in pursuance of a plan. The first, however, has only reference to the lowering from a higher level, which is determined by the prefix *de*. If there was such a word as *aggrade* it could be applied to the filling up of the lower level. But when neither prefix is used the word expresses both operations, and means the modification of the natural surface of the ground so as to coincide with some established grade, either level or inclined.

Although the building of culverts and protection walls or abutments and piers are necessary for the preservation of the works of grading, or substitutes for it in connection with arches and trusses where grading would be impracticable, such structures are not logically a part of the work of grading any more than are the iron rails which are necessary to form the upper surface of the road where it would be impracticable to use the materials of grading. The whole of grading is accomplished by the de-gradation of the hill and by the deposit of the materials of de-gradation in the valley; the same as is expressed by the two French words *deblai* and *remblai*.

The Baltimore & Ohio Railroad is the oldest in the United States, and their methods and practice in construction have been followed by nearly all the others. If you will refer to their earliest and latest records you will see that in all their advertisements for proposals and specifications for contracts three distinct divisions were constantly observed, namely, graduation, masonry and bridging, and contracts have been repeatedly made with one man for the graduation or grading, and with another for the masonry on the same section of the road. MASTER MECHANIC.

WHAT IS GRADING.

N. P. R. R. Co., Rocky Mountain Division,
HELENA, Mont., Jan. 3, 1 82.

EDITOR ENGINEERI G NEWS:

In reference to the question "What is Grading" I would suggest that in an experience of over 35 years I have seen and heard the word "grading" used by engineers and contractors almost, if not quite, invariably in contra-distinction from masonry and bridging.

All blanks prepared for making estimates make the above distinction. Railroad accounts do the same. All reports of the cost of railroads continue the above distinction, yet when non-professional persons attempt to speak of such matters it is not uncommon to see the word used in such a way as to indicate an intention to have it cover the entire construction of a road ready for the superstructure. The general railroad law of Montana makes it obligatory upon railroad companies organized thereunder to grade ten miles each year, as a condition of corporate existence. If a railroad company, which had simply "graded" ten miles of road without constructing culverts or bridges, should be attacked in court for forfeiture of charter, I should expect the higher courts to hold that the law had been complied with; but should some city agree to issue its bonds when the same railroad company had graded ten miles of its road, I should expect one-half of all the lawyers and more than one-half of all the inferior courts to claim that grading included bridging and masonry, because they could not be made to understand that those whose business it is to use that word most, use it invariably in an exact sense.

Grading is, no doubt, the principal operation in constructing most railroads, but it should not, therefore, be held to include all other operations.

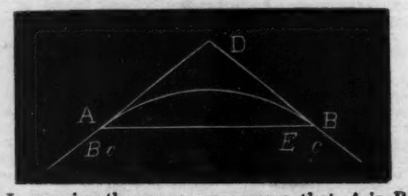
D.

ALIGNMENT OF COMPLETED RAILROADS.

PITTSFORD, N. Y., Dec. 26, 1881.

EDITOR ENGINEERING NEWS:

The questions of F. Miller in last week's issue appears to be very simple and easy to be answered. I do not know why it is any more difficult to determine the alignment of a road after it it built than to determine it before it is built. The tangents will show for themselves after it is built, and it appears that the only difficulty lies in locating the Bes and Ees. After running the curve line joining two tangents the whole amount of curvature in that curve will be known, and the length of chord joining the two ends of the curve and also the angles made by the chord tangent at each end. And if the angles at each end of the chord are nor equal, the beginning and end of the curve is located wrong, and must be corrected. Let D = deflection at the intersections of tangents, then the distance from (*Be*) beginning of curve to intersection will = rad. tang. ½ D.



In running the curve we assume that A is *Bc* and B is *Ec*, which are unequal distances from D.

$$\text{Distance } DA = \frac{AC \sin. B}{\sin. D} \qquad DB = \frac{AB \sin. A}{\sin. D}$$

The above equations show which way A and B must be moved to locate them at the beginning and end of the curve.

The second question: Multiply the deflection distance for 100 ft. by the square of the distance used and divide by 10,000. L. L. NICHOLS.

PROBLEM.—A freight car with an area of 100 sq. ft. front, loaded with 10 tons, including its own weight, starts down a grade of 34 ft. to the mile, in a straight line, everything in good working order. What speed will it attain to when its speed becomes uniform?

INACCESSIBLE DISTANCES.

FERRYSBURG, Ottawa Co., Mich., Dec. 27, 1881.

EDITOR ENGINEERING NEWS:

The scheme for the determination of distances and altitudes, as given by M. Kazimiski in your issue of the 10th inst. is well calculated, as you suggest, to draw out comment. It is a rare example of how far a person may go in a roundabout way to do a thing, instead of going directly at it.

It will be observed that the graduation which he proposes for his vertical arc is the reverse of that in our ordinary arcs—*i.e.*, he makes his tangent scale vary by *constant* increments, while his vertical arc varies by diminishing increments—these increments varying inversely as their corresponding secants; while in our instruments the tangent scale varies by *increasing* increments—the increase being directly as the corresponding secants—and our arcs vary by constant, or equal increments.

This change in the graduation of the arc appears to facilitate the measurement of horizontal distances, but is a total failure in the determination of heights or differences of level, if we regard simplicity and conciseness and amount of work in

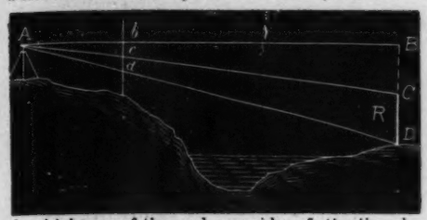
volved as being factors in the consideration of the question; moreover, it spoils the arc for other purposes.

The fundamental principle underlying this method consists in the comparison of the differences of tangents—a method capable of development with the instrument already in use, with or without the use of a vertical arc—better without.

An example will best illustrate:

In the accompanying figure let it be required to find the horizontal distance between the station *A* and the rod *R*, our instruments being the usual leveling rods with tape and the engineer's transit without vertical arc, or a Y-level.

Introduce an *auxiliary rod* between *A* and *R* at a known distance, say 100 ft. from *A*, and about



the thickness of the rod one side of the line between them, so that the horizontal wire of the telescope will cut both rods at one pointing.

Let the length between the two targets *D* and *C* on the rod *R* be assumed, an arbitrary constant, as large as practicable, say 12 ft.

Point the telescope at the upper target *C* of the rod *R*, and note the reading at *c* on the intermediate rod. Then train the telescope on the target *D*, and note the reading *d* on the intermediate rod.

The difference of the readings *c* and *d* gives us the intercept *cd*, which is the analogue of *CD*.

Then $CD \div cd = AB$ in terms of Ab,

for the triangles *ABC* and *Abc* are similar; as are also the triangles *ABD* and *Abd*, whence the differences *CD* and *cd* have the same ratio as the sides *AB* and *Ab*.

Numerically, let *cd* be found, say to equal .845 ft., then the rod *D* being 12 ft., and the horizontal distance *Ab*, being assumed at 100 ft.

$$AB = (12' \div .845') \times 100 = 1{,}420'.$$

If it is desired, also, to compute the differences of height between the "height of instrument" and the "height of hub," at rod *R*, we have only to note the *level* reading at *b*, on the intermediate rod, and multiplying the intercept *bd* thus found into the ratio of *CD* to *cd* already found.

Thus, supposing the intercept *bd* was found to be 2.126 ft., then

$$BD = (12' \div .845') \times 2.126' = 30.189'$$

which is subject to correction for refraction and curvature.

These operations are so simple and obvious as to require little or no further explanation; moreover, there is a degree of precision resulting from the introduction of the "intermediate" rod that is entirely unapproachable with any method of measuring vertical angles with the small arcs the instrument makers give us on our field instruments; for thereby we virtually read the limb of an arc having a 100 ft. radius.

It may be said that we require another helper by this method. So we do. But we have relieved the transit-man from all reading and recording of vertical angles, and of all consideration of these data in the office, which is more than a compensation for this extra assistant; besides, as before remarked, we have introduced a degree of precision utterly unattainable by *any other method*.

H. C. PEARSONS,
U. S. Inspector of Steam Vessels.

AMERICAN BRIDGE BUILDING IN THE ANTIPODES.

The Edgemoor Iron Company, of Wilmington, Del., have just completed the Nowra Bridge over the Shoalhaven River, New South Wales, and the bridge has been thrown open to public traffic. Mr. Onward Bates was the engineer in charge of construction. The bridge is the longest in New South Wales, its length being 1,103 ft., width 20 ft. and the heading about 22 ft. It is high level, having no opening for navigation but admitting of river steamers passing under easily. There are seven spans of 124 ft. 6 in. each; one span of 181 ft. 6 in.; and one of 50 ft., and with the exception of the timber planking the materials used are iron. In connection with the shortest spans, the iron cylinders upon which the structure rests are twelve in number and 5 ft. in diameter. In the long span the cylinders are four in number and 7 ft. in diameter. On the northern end there are ten cylinders 3 ft. 6 in. in diameter with stone abutments. The superstructure is of American design and is the first of the kind erected in the colony. Whipple trusses are used. It is for use now only as a highway bridge but is built to sustain railway traffic. Connected with it is a wooden bridge on stone piers over the Bomaderry Creek, of one 90-ft. span and two spans of 30 ft. This latter structure is connected with a wooden bridge of two 30-ft. spans on an embankment forming the approach to the creek. These also are built strongly enough to sustain railway traffic. The cost of the three structures is about $210,000.

NOTES.

EXCAVATORS AND DREDGERS IN PANAMA.

Contradictory accounts have been published from time to time of the machinery to be employed for the excavations in the Panama Canal works. The following description of them may be taken as an official one, having been published by the company itself. The excavator, designed by M. Couvreux, is in fact a dredging machine on dry land, with the necessary modifications to suit the different nature of its work. The excavator, however, cannot stand over its work like a floating dredger, and the endless chain with buckets is therefore placed at one side of it, and nearly horizontal, although some inclination is given to the chain according to the slope of the ground and nature of the soil. The buckets are then driven along the slope of the cutting, scooping out the earth or cutting it away like a succession of planes, and throwing it out on the other side of their round. The excavator can be placed either on the level from which the excavation is to be made, or—in case of a mass of earth to be removed—on the level down to which the soil is to be brought. In every case, it stands by the side of the place of work, upon rails of the normal gauge, and moves along continously while in action. After it has reached the end of the rails they have to be shifted, either to bring it again alongside of the remaining mass to be leveled, or to remove it further from the trench. The great weight of the chain of buckets, with all its apparatus, coming entirely upon one side, and the tremendous strain of the work, so unequally distributed, made the question of securing the balance of the machine a very difficult one. This has been effected by various expedients, of which the principal has been the use of a third wheel on each of the four axles, working on a third rail 20 in. within the outer rails on the side of the chain. The excavator is furnished with two engines; one of 20 horse-power drives the chain; the other, of only 4 horse-power, moves the machine on the rails. The appearance of the whole is like a very tall locomotive, and the total weight is somewhat over 44 tons. The buckets contain about 6 cu. ft. each, and their number varies according to circumstances. They can be driven to the depth of 16 ft. The excavator works at the rate of 80 turns per minute, and on an average (allowing for loss of time) excavates and loads on trucks 84,600 cu. ft. of earth per day, thus doing the work of fully 600 laborers. It only requires the services of a driver, stoker and two workmen for various purposes, besides the men who remove the rails, which only takes up a portion of their time. The dredging machines employed in this work are of great size and power; they are 110 ft. long by 21 ft. broad, and weigh when empty about 081¼ tons. The buckets contain about 10 cubic feet each; they can be driven nearly 30 ft. deep, and lift their contents to such a height that they can be shot to a distance of 133 ft. The average of work done is nearly as great as that of the excavator.

THE PANAMA CANAL.

A complete account has now been published of the proceedings of the superior consulting committee of the Panama Canal works, which assembled in Paris for its first session on November 25. A report drawn up by the consulting engineer, containing the proposals of the administrative council for the second phase of the work, was laid before the Commission, and served as the basis of its deliberations. It is considered that the best opening for the canal at its eastern end into the Bay of Simon will be by the way of the mouth of Folks' River. A cutting through the Mindi Hills would bring the canal from Folks' River to join the River Chagres, whose bed is also to be taken advantage of for a considerable distance; and it is proposed to begin it very soon, and make a sort of temporary canal for immediate use on the line of the great one, so as to establish water communication with Gatun, on the Chagres. The administration asked permission to begin work at once at two points; upon the rocks between the falls of the Obispo, and at the highest point of the cuttings, the top of the Cerro Culebra, where, however, the soil is argillaceous. Here preliminary cuttings will be made, which will give more accurate knowledge of the nature of the ground than can be derived from any number of soundings. According as the earth is removed, it will first be piled up in banks to protect the cuttings from becoming drains for rain water, and then gradually be used for a tramway from the Culebra working to the Gamboa dam to convey thither all the remaining débris. We have mentioned this dam before and now need only add that owing to the great depth at which the solid rock lies at that spot it has been decided not to attempt to make any foundation, but simply to heap the materials on the surface of the ground. A wall of great blocks of stone will cross the valley. Inside and above it will be laid in order small blocks, rough stones, pebbles, gravel, sand and clay, and the Culebra débris. Arrangements will be made to prevent flooding during the course of the work. The Commission assented (after deliberation) to these and all other proposals of the administration, with a few slight qualifications.

THE ADIRONDACK SURVEY.

Commendable progress has been made in the survey of the Adirondack region heretofore authorized by the Legislature. An important permanent basis for all leveling work in the northern counties has been made the past season, by the location of a line of geodetic levels, carried northward from Albany through two degrees of latitude, and forming, in connection with the United States surveys, a continuous line of reference levels with monuments from New York harbor to the Canadian frontier. Valuable work has also been accomplished under the direction of the superintendent of the Adirondack survey in relocating the boundary lines of Essex, Franklin, Hamilton, Herkimer and Lewis counties. Evidences of former surveys were generally extinct, and in one instance every vestige was obliterated for a distance of thirty-five miles. Township lines were also found to be in great confusion, rendering assessments for taxation difficult and causing much embarrassment in the collection of taxes. Provision should be properly made for the location and permanent marking of these obscure and missing lines, so as to avoid constantly recurring difficulties, both as to local jurisdiction and the ownership of adjacent lands. The reports of the Adirondack survey have been largely sought by the public, and in authorizing future publications it may be well for the Legislature to consider the practicability of having them placed on sale. It is not unlikely that the expense of publication would be partially if not wholly met by this means.

Pertinent to matters relating to the survey above referred to, is a subject suggestive of practical observation in regard to the northern wilderness. The vast tract of country lying in the northern part of the State, familiarly known as the Adirondack region, has become one of the most inviting resorts to invalids and tourists. Its high altitudes, pure and bracing atmosphere, perennial streams and mountain lakes, in the shade of primeval forests, constitute the desirable features of a retreat designed by nature for the uses of mankind in pursuit of health or pleasure. But there are other and grave interests belonging to this portion of our territory that appeal with especial force for timely consideration. By far the greater quantity of land within the Adirondack wilderness proper belongs to the State. Individual ownership is now confined to a few hundred thousand acres. Heretofore it has been the practice of the State, with questionable policy, to sell its wild lands at nominal prices to private parties, who have gone on in most cases, and cut off the marketable timber where accessible, and then abandoned to the State the clearings, worthless generally for agricultural purposes, thereby escaping the payment of taxes. Forest fires have followed and raged with destructive fury, denuding the mountains and checking the flow of springs and streams that supply the navigable waters to the north, and the Hudson River southward. Furthermore, many of the lakes, the natural reservoirs of the mountain courses, have been damaged by dams and overflow, so that the shores of those lying within the working timber limits present the effects of irreparable injury. It has, therefore, become a question of serious import whether the State should any longer part with its title to land in this quarter, now held or that may hereafter revert by the non-payment of taxes. It might be leased, perhaps, with safety, for certain purposes; but its uses should be carefully restricted.

The Adirondack region is the natural and principal water-shed of important navigable waters, and, if it be divested of its timber, imminent danger will threaten. The rain-falls will diminish, the springs and streams fail, and unaccountable loss ensue to interests not immediately located in that part of the State. This subject will, indeed, sooner or later demand inquiry, if its importance does not now compel investigation.—*Gov. Cornell's Message.*

GUNPOWDER.

The ingredients in gunpowder are saltpeter, charcoal and sulphur; slightly different proportions are employed in different countries; in the United States the proportions are 75 to 76 saltpeter, 14 to 15 charcoal and 10 sulphur. Charcoal is the combustible ingredient; saltpeter furnishes the oxygen necessary to support a rapid combustion and to change the whole mass into gas, and sulphur adds consistency to the mixture and

intensity to the flame, besides rendering the powder less liable to absorb moisture, and increases the volume of gas by preventing the formation of a solid potassium carbonate and by increasing the temperature. In the manufacture of ordinary powder the operations usually employed are pulverizing the ingredients, incorporation, compression, granulation, glazing, drying and dusting When Ghengis Kahn invaded China, B. C. 1219, firearms of a primitive form appear to have been used. Passages in old writers seem also to show that when Alexander invaded India, 327 B. C., he encountered tribes that used similar weapons. It is probable that the invention of powder arose in Central Asia, in the regions where saltpetre occurs as an effervescence of the soil. The use of gunpowder is mentioned in Arabic writings in the 13th century, but its use in Europe can be traced only to the middle or early part of the 14th century. The powder used in the United States is principally "Hexagonal powder," and in the United States service five kinds of grain powder are used, all made in the same manner, of the same proportions of materials, and different only in the size of the grain, namely: "Mammoth," "cannon," "mortar," "musket" and "rifle" powder. There are other powders with trade names given them by the respective manufacturers. Powder for rifles is made with special reference to the attainment of a high initial velocity with a moderate press on the bore; it has a density of 1.80 and a size of grain which will pass through sieves of 16 meshes to the inch and lie on one 24 to the inch. In selecting powder take note that it should be uniform in color, density, size and shape of grain; difference of color indicates a difference in the inflammability of the charcoal used; difference in the shape of grain, that of density; the largest and smallest grains may with advantage be removed by sieves of proper sizes.

A CANAL BOAT PROPELLED BY AIR.

A novelty in canal boats has recently been constructed at Wiscasset, Me., after designs devised by the owner, who claims to hold patents for the design in the United States and England. The first boat built is lying at the mouth of Charles River, Boston, where it has been examined with much interest by engineers and others. It is designed to be used on canals without injuring the banks; it is a simple structure, measuring 62 ft. long and 20 ft. wide. It is 3 ft. in depth and draws 17 in. water. It is driven entirely by air, a Roots blower No. 4 being used; the latter operated by an 8 horse-power engine. The air is forced down a central shaft to the bottom, where it is deflected, and, being confined between keels, passes backward and upward, escaping at the stern through an orifice 19 ft. wide, so as to form a sort of air wedge between the boat and the surface of the water. The force with which the air strikes the water is what propels it. The boat has a speed of four miles an hour, but requires a 35 horse-power engine to develop its full capabilities. The patentee claims a great advantage in doing away with the heavy machinery of screws and side wheels, and believes that the contrivance gives full results in proportion to the power employed.

DISPOSING OF SEWAGE.

In the current number of *The Sanitarian* Dr. H. G. Beyer, United States Navy, describes the method of treating excreta with Suvern's deodorizer in one of the Leipzig hospitals. This deodorizer is a pasty mass with the following composition: In 100 parts there were water, 61.5; lime (CaO), 30.5; chloride of magnesia ($MgCl_2$), 1.5; tar, 1.2; foreign matter, 5.3. In manufacturing the deodorant, crude lime and magnesia being used, it is from this source that a great deal of foreign matter is introduced into it. A certain amount of the mass is dissolved in water and poured into the closets, where it is retained until the process of disinfection is completed. The resulting mixture is then allowed to run through the closet pipes into the drain pipes, and thence into a specially prepared reservoir where one part of it is precipitated, and the clear, supernatant liquid is then run off into the sewers. How thorough the action of this deodorant is, says Dr. Beyer, was seen by a specimen of the liquid taken out of the reservoir and reserved for analysis. This liquid was almost colorless, had only a faint smell of tar, and did not seem to decompose, even after long standing. It contained 0.353 parts of solid residue in one litre, consisting for the most part of chloride of ammonium and lime, and having an alkaline reaction. The precipitate is finally dried and carted away.

NEW YORK TENEMENTS.

The main outcome of the tenement house agitation, which attracted so much attention three years ago, was a legislative act that has proved a most wholesome remedial measure. During that period hundreds of tenement houses have been built, but there is not one in which there is a single room that does not have direct air and light. So effectual is this remedial agent that the sanitary officials are boasting that the tenement houses recently built are in advance of private residences in sanitary conditions. If the new plumbing act proves as useful in effecting thorough drainage as this building act has been in letting in air and light, the lodging places of the poor will be permanently improved. These are the new homes of the working people. The old tenement houses remain damp and foul, for the radical defects of construction are not affected by recent legislation. Progress has been made, however, in the right direction. Let the health of the lower classes be promoted, and good morals and useful citizenship follow as a matter of course.

MISCELLANEOUS.

ENGINEERING PERILS.—A detachment of the Second Cavalry from Fort Custer has been sent to Terry's Landing, on the Upper Yellowstone, to protect the Northern Pacific engineers and the construction company from the marauding Crows.

THE ADIRONDACK RAILROAD'S FUTURE.—Dr. Durant proposes to reorganize the Adirondack Railroad Company and complete the road to the St. Lawrence River. It has not been decided whether the road will strike the St. Lawrence at Ogdensburgh or at a point where Kingston can be reached, and a direct New York and New England connection made for the Grand Trunk from that point.

THE CERRO GORDO.—CHARLESTON, Ill., Dec. 24.—A full corps of engineers arrived here to-day, having completed the survey and final location of the Cerro Gor o Short-Line railroad from Marva, on the main line on the Illinois Central Railroad, to this city. They report that at no place is the grade more than fifteen feet. After the holidays they will proceed locating an extension to Louisville, Ky., the intention being to have a line from Peoria, Ill., and places beyond the former city in Kentucky.

LOCOMOTIVE BUILDING.—Five hundred locomotives have been built in the three Paterson establishments during the past year, worth upward of $5,000,000. The price ranges from $8,000 to $14,000, according to size and character. This is the largest number ever turned out in Paterson in any one year. The business has been conducted almost entirely on a cash basis. The prices obtained have been very much lower than in former years and the profits correspondingly less, but the losses have also been much below the average in consequence of the cash policy pursued. From present appearances, fully 600 locomotives will be completed in the same city next year.

A NEW BOSTON & CHICAGO R. R.—Engineers are surveying a route for a new railroad from Danby, Vt., by way of Tinmouth, Middletown, Poultney, Castleton, Fair Haven and Orwell, to a point on Lake Champlain, opposite Ticonderoga, where the lake will be bridged. The distance is fifty-five miles. Another road is contemplated from South Shaftsbury, Vt., by way of Bennington to the Hoosac Tunnel. These lines, with the Bennington & Rutland Railroad, would provide a new route from the tunnel to Ticonderoga. It is proposed to connect Ticonderoga by a road through the North Woods with Sackett's Harbor, and, by forming western connections with the Grand Trunk Railroad and eastern connections with the new Massachusetts Central Railroad at the tunnel, make a route from Chicago to Boston, 150 miles shorter than any now in existence.

A BIG RAILROAD BORE.—The tunnel of the Denver & South Park division of the Union Pacific Railway through the main range of the Rocky Mountains, at an elevation of 11,525 feet, has recently been completed. The length of the bore is 1,776 feet, the height 16½ feet, and the width 13 feet. It is arched and timbered with California redwood. Nearly 500,000 feet of this timber have been used in the construction of the tunnel. The cost of this wood, including the freight charges upon the Central Pacific, was from $80 to $110 per thousand feet. The formation through which this tunnel was cut is composed of slide-rock, bowlder, and decomposed granite. The amount of false timbering used was not less than 1,500,000 feet. This was hauled over the mountain through over an average of seven feet of snow, and a few snow-banks from fifty to sixty feet in depth. Last winter the laborers had to sink a shaft thirty feet in depth, through packed and frozen snow, to reach their work. During violent storms the workmen, in going to and from their cabins, were obliged to move in gangs, to avoid being lost in the snow, and frequently their clothes were frozen to their skins. The contract cost of the tunnel was $275,000.

THE PENNSYLVANIA RAILROAD.—Mr. Slataper, Chief Engineer of the Pennsylvania Company's lines, was in Chicago recently. He says his whole attention is given to watching the movements of encroaching railway lines in the vicinity of Pittsburgh. The hillsides and valleys in that section are gridironed with embryo railroad routes. Land-holders on these projected lines are asking fabulous sums for rights-of-way. He says the Pittsburgh, Fort Wayne & Chicago Railroad Company are preparing to build two additional tracks from Pittsburgh outward for a distance of twelve or fifteen miles. This enlargement of track facilities is required to meet the increasing volume of business at that point. Mr. Slataper, speaking of the report started by an Indianapolis newspaper, and reproduced in many other sheets, foreshadowing important changes in the executive management of the Pennsylvania system of roads, said there was not the slightest probability that any such changes would occur. He said the present high officials are in perfect accord, and no one is scheming for the overthrow of anybody else. Mr. Slataper is here to settle with the city authorities for the company's share of the expense of building the Harrison street viaduct.

THE C. P. R. R. IN ENGLAND.—A pamphlet has just been published in London, entitled "The Canadian Pacific Railroad and the Schemes of the Syndicate," warning the English people not to invest their money in what is represented to be a reckless enterprise. "The Canadian Pacific," the pamphlet says, "takes its only course through the unpeopled valley of the Saskatchewan and the district called the Fertile Belt, but it can have no extensions northward, except the Arctic regions, and no branch in that direction except to the north pole, while southward it has its rival in the Northern Pacific of the United States. For six months the road will be an ice-bound, snow-covered route, through districts many hundreds of miles further removed from the great marts of the world, and from the cities and ports served by the railways which traverse in every direction the Golden Northwest and the granaries of the world. Over the whole of the territory through which the road is proposed to run, there is not, with the exception of Winnipeg, a single town, or city, or settlement of any importance. No intimation has yet been given of the existence of any deposit of the precious metals, or of other sources of mineral wealth, such as those on the line of the Union Pacific. The section of 650 miles between the proposed junction at Callender with the Canada Central & Thunder Bay is a perfect blank, even on the maps of Canada, and all that is known of this region is, that it would be impossible to construct this one section of the railway for the whole cash subsidy provided by the Canadian government for the entire scheme, including 2,750 miles at $25,000 per mile. The district north of Lake Superior may be regarded as wholly and absolutely unfitted for agricultural settlements or for railway construction or working."

RAILROAD CONSTRUCTION IN 1881.—We append a table showing the railroad construction of the country for 1881. The total number of miles constructed was 8,603, the largest of any year on record, making the total mileage for the whole United States and Territories at the close of 1881 102,274 miles. The remarkable increase in railroad building is the natural result of the prosperity of the past few years and the rapid development of country following the vast tide of immigration to the United States from all parts of the world. The sections of country which have profited most from the enormous sale of grain, cotton and hog products since 1878 have acquired the largest number of new railway lines during the year. Thus of the 8,603 miles of road built during 1881, 3,383 were in the Southwestern States, 2,286 in the Northwestern States, 1,231 in the Southern States, and 1,135½ in the Pacific States. Of the 462½ miles constructed in the Middle States 219 were in New York and 113 in Pennsylvania. It is hardly probable that the coming year will be as prolific of railroad enterprises as 1881, in view of the fact that excessive railroad building makes capital timid and that investors have already suffered losses by placing their money in roads which are being built in advance of the requirements of the sections traversed. In this respect the liquidations on the Stock Exchange will have a wholesome influence; in fact, they have already effectually stopped many wild schemes about to be launched upon the public. The following shows the railroad construction for the year 1881:

	Miles.
New England States	105
Middle States	462½
Southern States	1,231
Northwestern States, etc	2,286
Southwestern States, etc	3,383
Pacific States	1,135½
Total United States, etc	8,603

MISSOURI RIVER "IMPROVEMENTS."—A prominent business man from the upper Missouri, who wants his name withheld, for obvious reasons, upon being interviewed on the proposed appropriation for the improvement of the Big Muddy from Cow Island down, says: "I'm not opposed to its improvement. To have it made easily navigable during all the spring, summer and fall months, barring the cold parts, of course would mean a good many hundreds, I may say thousands, of dollars to me; but I tell you honestly that except for the good the money would do the working classes you might as well throw it into one of the sand boils on the treacherous stream. They talk of $10,000 per mile, and some of my friends wanted me to attend the convention at St. Joe as a delegate and help whoop-up the project. They might as well ask for $10,000 an inch while they are about it, for that wouldn't be enough. It hasn't banks, bottom, or direction. Every freshet makes a practically new river, and you can't fill the maw contained in a couple of rods of water by piling in all the stone you can haul. They put in ninety car-loads in a short piece between Kansas City and St. Joe to secure a railway track, and one of the contractors told me you wouldn't know they had ever done a dollar's worth of work there. Not a stone is in sight, nor can one be felt by prodding under the water and mud. Wing dams and slough dams go out at the first rise, for there isn't any way of securing them. Those dams on the Yellowstone, although that isn't as bad a stream as the Missouri, will be gone next May. Now, above Cow Island the stream is different, and the work done by the Government engineers there amounts to something. It's a good and valuable job, and when they finish they will receive the thanks of steamboat men. But below, as I said, a child could see that money, no matter if it was spent like water, can avail nothing in the way of permanent good, and to appropriate it is all foolishness. The Yellowstone is different, and maybe something could be done with it. In my judgment the best way would be to build two dams across it. I first thought of this by seeing, when boating on the Yellowstone, ridges running straight across the stream and sometimes nearly two feet high. To one who didn't know it would appear like an obstruction, but there was always plenty of water on the natural dams which were made by a step, or terrace, in the bed of the river. If there were more of them I am inclined to believe navigation would be better."—*Chicago Times.*